Single-Route and Dual-Route Approaches to Reading Aloud Difficulties Associated with Dysphasia

A thesis submitted in fulfillment of the regulations governing the Degree of Doctor of Philosophy of The Open University.

by

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30th September 1999

ABSTRACT

The study of reading aloud is currently informed by two main types of theory: modular dual-route and connectionist single-route. One difference between the theories is the type of word classification system which they favour. Dual-route theory employs the regular-irregular dichotomy of classification, whereas single-route considers body neighbourhoods to be a more informative approach. This thesis explores the reading aloud performance of a group of people with dysphasia from the two theoretical standpoints by employing a specifically prepared set of real and pseudoword stimuli. As well as being classified according to regularity and body neighbourhood, all the real word stimuli were controlled for frequency. The pseudowords were divided into two groups, common pseudowords and pseudohomophones, and classified according to body neighbourhood.

There were two main phases to the study. In the first phase, the stimuli were piloted and the response time performances of a group of people with dysphasia and a group of matched control people were compared. In the second phase, a series of tasks was developed to investigate which means of word classification best explained the visual lexical decision and reading aloud performance of people with dysphasia. The influence of word knowledge was also considered.

The data was analysed both quantitatively and qualitatively. The quantitative analysis of the number of errors made indicated that classification of items by body neighbourhood and frequency provided the more comprehensive explanation of the data. Investigation of the types of errors that were made did not find a significant relationship between word type and error type, but again the results indicated that the influence of frequency and body neighbourhood was stronger than that of regularity. The findings are discussed both in terms of their implications for the two theories of reading aloud and their relevance to clinical practice.

ACKNOWLEDGEMENTS

There are many people whose help and support I wish to acknowledge. Linda Armstrong has been a dedicated supervisor, providing advice, moral support and endless encouragement. It is due to her input and enthusiasm that I have learned so many new skills and greatly enjoyed this research experience. I cannot thank her enough for all that she has done for me. I would also like to thank my other supervisors for their continued support and assistance. Richard Shillcock for his expert knowledge and enthusiastic advice which have helped me to always try and see the wider picture and Christine Skinner for her great patience, efficiency and gentle encouragement.

I would like to thank all the people who took part in my study for their involvement and also the therapists who helped me in my endless search for suitable participants, particularly Linda Greig and Patricia Lyle. I would also like to thank my colleagues at Queen Margaret University College. They have all been supportive and generous with their time, but I would particularly like to thank Heather McCleish and Karen Horton for their patience and administrative assistance and Jois Stansfield for all the support she has given me.

All my friends have given me a great deal of encouragement and reassurance and I am grateful to them all for their support. I would particularly like to thank Martha Lester-Cribb, my friend and neighbour, for all her help. She has been a willing provider of technical support, sympathy and chocolate at all hours of the day and night and has made the few weeks prior to the submission of my thesis much less stressful than they might otherwise have been.

Finally, I would like to offer my greatest thanks to my parents, my mother Nan and my late father David Mack. It is due to their support, encouragement, advice and love that I have succeeded in completing this thesis.

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CHAPTER ONE: INTRODUCTION

1.1 THE INVESTIGATION

Reading aloud is one of the least common language-associated activities in everyday life (Lesser & Milroy, 1993) and in the light of the many speech and language difficulties from which a person may suffer following a stroke, problems with reading aloud may seem to be of little importance. Consequently their investigation and remediation is rarely a priority, particularly when therapy resources are limited. This attitude to reading aloud ability may be justifiable as it is indeed of relatively little use, particularly when compared to other aspects of language such as comprehension and spontaneous expression. However, Nickels (1995) cautions against ignoring the possible value of further exploration of the status and rehabilitation of this skill. She briefly describes four individual cases from the literature in which the remediation of acquired dyslexia appears to have been responsible for improvement in other aspects of language which are of greater practical use, specifically naming ability and reading comprehension.

If, as Nickels (1995) suggests, remediation of acquired reading difficulties can effect functionally significant changes in the more general language performance of people with dysphasia, then the study of reading aloud impairments caused by neurological damage and the theories relating to such studies are potentially of great interest to clinicians. Studies of reading aloud to date have tended to concentrate on detailed investigations of a single case who has shown a specific and often isolated difficulty in this particular area of language processing. Nickels' (1995) findings may have implications for people with less extreme manifestations of these disorders who might also benefit from some specific intervention. In order to take full advantage of any such potential clinical benefits, it is important that any assessment of reading aloud prior to possible remediation be both thorough and theoretically valid. A preliminary study of the means currently employed to undertake such a task suggested that this was an area worthy of further investigation.

Currently there are two major approaches to the study of reading aloud, the classical dual-route theory and the connectionist single-route, each of which employs a different type of word classification. Simply defined, these methods revolve around issues of word regularity and consistency. It was proposed that a thorough investigation of performance on carefully selected and controlled stimuli categorised according to both these methods would give insight into which system provides the more useful account of word reading difficulties.

1.2 RESEARCH QUESTIONS

Illuminating the optimum method of assessing reading aloud in adults with dyslexia forms the central aim of this thesis. Working from the null hypothesis that there would be no difference in the success of the classifications of regularity and consistency at providing a comprehensive account of reading aloud difficulties, a number of questions are addressed:

- Is there a difference in performance across different word types and classifications by people with mild-moderate aphasia?

- Are the types of errors which are made in reading aloud in any way related to word type?
- Is there a relationship between knowledge of word meaning and reading aloud success?

1.3 AIMS

To answer these questions several tasks were devised, with the following aims:

- To provide detailed evidence of the reading aloud errors made by adults with dysphasia.
- To investigate the underlying nature of these errors by considering both their type and the participants' comprehension of the words which they read aloud incorrectly.

1.4 THESIS OUTLINE

The following chapter contains a review of the literature which considers a number of theories of reading aloud and their concomitant models. It focuses on how these theories claim to explain the various manifestations of acquired reading disorders. It aims to place in context the development of the types of word classification systems which are currently used to test reading aloud skills.

A series of studies aims to determine which is the more successful means of word classification in terms of describing the performance of people with dysphasia. The preliminary task (Chapter Three), a Response Time (RT) task, compared the pronunciation latency scores of a group of people with dysphasia and a group of matched controls. This task also served as a pilot study for the use of response time measurement as a clinical tool. Of the main tasks (Chapter Four), the Visual Lexical Decision (VLD) task and Reading Aloud (RA) task investigated the performance of a group of people with dysphasia on a large number of tightly controlled stimuli, in order to investigate factors of word type which might affect performance. The Reading for Meaning (RFM) task examined whether the words that were read aloud incorrectly were known or unknown to the participants. The effects of word type on these tasks and the analysis of the types of errors made in the RA task are reported in Chapter Five. The final chapter discusses the findings in the light of the current theories of reading aloud and in terms of their implications for clinical practice.

CHAPTER TWO: LITERATURE REVIEW

2.1 CHAPTER OUTLINE

This chapter will trace the development of a number of theories of reading aloud with the aim of providing a comprehensive account of the current models and their implications for clinical practice. Particular attention will be given to the way in which these models are able to offer an explanation for the patterns of reading disorder caused by neurological damage or degeneration, the dyslexias.

It will be shown that many of the supposed differences between the various theories and their concomitant models are insignificant and that the most clinically, and possibly theoretically, apposite factor is the type of words which are employed in the testing of both clients and models. A detailed account of the two most common types of word categorisation in this field and their relationship with contemporary theories of reading aloud will provide the basis of the current investigation.

2.2 READING ALOUD SINGLE WORDS: CLINICAL JUSTIFICATION

All the theories to be described here focus on the reading aloud of single words, as a deficit of sentence reading may reflect the presence of a larger deficit of cognitive or language processing and not a problem of reading aloud per se (Friedman, 1988). The study of reading aloud might seem even less important than Lesser and Milroy (1993) implied if it is to be reduced to the exploration of single word reading, yet it is the area of cognitive neuropsychology which has been most heavily investigated (Behrmann & McCleod, 1995) and as an intrinsic element of the general process of reading, single word reading is arguably a vital skill (Tzelgov, Poart & Henrik, 1997).

The translation of written symbols to sound is the basis of the reading process and it is a language skill that is unique to reading (Venezky, 1967). The existence of such a translation process provides a huge scope for investigation. The clear boundaries imposed on such investigations by the distinction between reading and other areas of language (due to the "uniqueness" of the reading process) have made the study of the possible mechanisms of reading aloud appealing to many researchers.

The impairment of reading ability is one of the most common effects of focal brain damage (Whitney, Berndt and Reggia, 1994) so there have been many opportunities for researchers to study this aspect of language and its rehabilitation.

2.2.1 STUDIES OF READING ALOUD

There are other studies which appear to support Nickels' (1995) claim that the study and rehabilitation of disorders of reading may be more widely applicable than is generally supposed. Howard and Franklin (1987) found that their patient, MK, made similar errors in oral picture naming and in oral word reading. After further investigation they concluded that he utilised orthographic information in naming and they therefore proposed that attention to his orthographic difficulties might improve his naming skills.

Functional magnetic resonance imaging (fMRI) has been used to study brain reorganisation in a dyslexic patient and the results suggest that it is possible for brain physiology to alter following therapy for acquired language disorders. Small, Flores and Noll (1998) describe a patient initially diagnosed with poor pseudoword reading whose reading skills improved following therapy and whose main focus of brain activation was found to move from the left angular gyrus to the left lingual gyrus. Although such investigative techniques are relatively new and unproven with regard to rehabilitation studies, these initial findings suggest that the study of reading disorders and their remediation may be of real functional use.

2.2.2 ASSESSMENT OF READING ALOUD

The key to providing effective rehabilitation lies, at least in part, in the appropriateness and quality of the chosen means of assessment (Webb, 1987), and the value of such an assessment and the subsequent treatment rely in turn on the validity of the theory from which they are derived (Behrmann & McCleod, 1995).

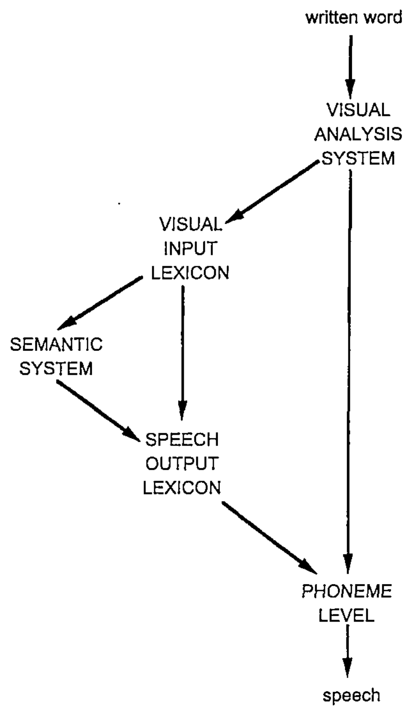
The relationship between the investigation and treatment of acquired reading disorders and models of normal reading aloud can generally be regarded as a mutually informative one. Not only do the models influence issues of assessment and rehabilitation, but frequently the outcomes of investigations of such interruptions to the normal process of reading aloud are regarded as important sources of information for the testing and further development of the models themselves (Patterson, 1981; Caramazza & McCloskey, 1988; Garrett, 1992). Indeed, it often appears that the main purpose of investigations of dyslexia has been to refine the theories rather than advance the cause of affected subjects (Behrmann & McCleod, 1995). There is a certain irony in the fact that it was the investigation of such dyslexic disorders by Marshall and Newcombe (1973) that inspired an interest in the further development of models of normal reading.

2.3 DUAL-ROUTE THEORY

There have been many diverse influences on the development of English spelling (Ellis, 1993) and several attempts have been made to delineate rules to make it more comprehensible to both new and foreign learners of the language (Wijk, 1966; Venezky, 1970). The English spelling system might best be described as quasi-regular in structure, i.e. it is systematic but admits many exceptions (Seidenberg & McClelland, 1989). Consequently, the linguistic evidence provided by these rule-based spelling systems has led to proposals that English words be divided into two mutually exclusive and exhaustive classes, a large group of systematic words whose pronunciation is regular as regards its spelling-to-sound correspondence e.g. *bug*, and a smaller exception, or irregular, group e.g. *cough* (Coltheart, 1978).

Psychological support for this division has come from studies which have shown that skilled adult readers are able to both recognise and read aloud regular words more quickly than irregular words (Baron & Strawson, 1976). Evidence such as this, coupled with the findings of Marshall and Newcombe (1973) that some patients who had suffered brain injuries were still able to pronounce regular words but failed to pronounce irregular words with the same level of competence, led to the development of complex cognitive models of reading aloud. The first such models of reading were based on a dual-route principle, whereby regular and irregular words could be pronounced by separate mechanisms or routines (routes), thus providing an explanation for the aforementioned findings of a dissociation in performance on the two types of words. One version of the dual-route model that is in common theoretical and clinical usage is shown in Figure 2.1 below.

Figure 2.1: The Dual-Route Model



From Ellis (1993, p.25)

2.3.1 THE FUNCTIONAL ARCHITECTURE

Complex cognitive processing is most easily explained in terms of flow diagrams which illustrate the existence of separate, specific processes and their interconnections (Quinlan, 1991). The boxes represent stores of information and the processes by which those stores can be accessed and utilised, whilst the arrows represent the communication links between the boxes (Byng, Kay, Edmundson &

Scott, 1990). This modular structure is of particular use when aiming to demonstrate how some functions may be impaired whilst others remain intact, as is so often the case with acquired disorders of reading. It has even been postulated that the individual modules might, in some manner, map onto specific anatomical structures. Damage to a given structure would be reflected in an impairment of that particular aspect of functioning (Ellis, 1993), but until the advancement of the techniques of those such as Small et al. (1998) (c.f. 2.2.1), this remains only a theoretical possibility.

2.3.2 THE PROCESS OF READING ALOUD

According to this model, when a word is presented to a reader it is processed first by the visual analysis system. This is thought to consist of letter-recognisers which analyse the components of the input letter string and encode each letter for its position within the string (Ellis & Young, 1988). The encoded output is then passed to the adjacent modules for further processing.

The right-hand route in Figure 2.1 is the one where it is proposed that spelling to sound rules are applied in order to assemble a pronunciation. Generally, according to this mechanism, the grapheme is the basic functional unit of translation and words are converted from print to pronunciation through the grapheme-to-phoneme correspondence (GPC) system. By this route, regular words and pseudowords, e.g. plew, can be pronounced correctly.

The alternative route, on the left hand side of Figure 2.1, is the mechanism through which it is assumed that any word already known to the reader can be processed accurately. In this case the pronunciation is derived not by the application of abstract spelling-to-sound rules, but rather by retrieving the pronunciation of the whole word directly from a storage component, in which all words already known to the reader are stored. This storage facility is called the mental lexicon. The involvement of the lexicon in this route has often resulted in its being referred to as the lexical route and, in contrast, the GPC route is often labelled the non-lexical route.

2.3.3 SURFACE DYSLEXIA

It is damage to the lexical route that is considered to be responsible for the inability to read irregular words in the presence of unimpaired regular word reading (Coltheart, 1981). Marshall and Newcombe (1973) reported two patients who displayed errors which they considered were mainly due to partial failures of GPC, such as incorrect voicing (disease→decease) or assigning phonetic value to a silent consonant (island→izland), but whose reading of regular words appeared to be unimpaired. This disorder is termed surface dyslexia and, in addition to the better naming of regular words, other characteristics include the retained ability to read pseudowords and attempts to regularise irregular words e.g. pronouncing *pint* to rhyme with *mint* (Patterson, 1981). Damage to the lexical route is argued to force reliance on the phonological or GPC route and thus an incorrect, regular pronunciation is generated for irregular words. The existence of this disorder is often considered as proof positive of the necessity of the two route model.

However, surface dyslexia (although well documented in the literature, most notably in the volume of that name by Patterson, Marshall and Coltheart, 1985), seems unlikely to be as straightforward to explain as simply being due to the disturbance of one route and the subsequent reliance on the other unaffected route. Patterson (1981) states that reading errors in surface dyslexia should reflect operation of the GPC route and therefore should not display a lexical influence. She claims that the fact that they do reflect such an influence means that it must either be concluded that surface dyslexia reflects a more complicated combination of the two routes or that the GPC route itself is more complex than was initially supposed. Friedman (1988) was unable to find reports of any pure cases of the disorder and Ellis and Young (1988) are of the opinion that as a number of patients demonstrate different error patterns, the fact that all subjects show difficulty with irregular words and produce regularisations is insufficient to justify categorising them as an homogeneous group. Even the production of regularisation errors is in some doubt. Friedman and Kohn (1990) report a subject who might typically be considered to have surface dyslexia, but of his 622 reading aloud errors only 6 (1%) could be classified as regularisations.

According to Patterson (1995), most cases of surface dyslexia caused by cerebral vascular accident (CVA) show a rather weak pattern of the disorder compared to those affected by progressive neurological conditions and this may be partially responsible for the incongruity of symptoms amongst reported cases. Another possible explanation is that surface dyslexia is better viewed as two sub-divisions of a wider syndrome. Shallice and Warrington (1985) argued against surface dyslexia as a central dyslexia and postulated that it was in fact the result of a compensatory procedure and therefore not relevant to the understanding of the normal reading process. They suggested that although errors representing partial failure of GPC rules could be due to an impaired phonological route, they could also be an example of letter-to-sound by letter-to-sound reading. They argued for differentiating this kind of dyslexia from what they termed semantic dyslexia – a syndrome in which the prototypical error is a perfect regularisation. As has already been discussed, regularisation errors seem relatively rare so the value of further sub-dividing the syndrome on this basis may be minimal.

The real reason for the variable clusters of symptoms which can appear under the blanket term of surface dyslexia may be that, in terms of the dual-route model, damage to any one, or more, of several cognitive loci could be responsible for the manifestation of the disorder (Humphreys & Evett, 1985). It appears impossible to isolate the exact area of deficit. Humphreys and Evett, whilst agreeing with Coltheart (1981) that the difficulties might arise due to a failure of access to *or* exit from the visual input lexicon, suggest that it could be problems with accessing either the semantic system (which would prevent transmission of information from the input to the output lexicon) or the phonological output lexicon (which would mean that a pronunciation could not be obtained) which are giving rise to the difficulties.

Thus, although the dual-route model is able to explain the occurrence of the gross symptoms of surface dyslexia it is unable to be specific as to the location of breakdown. If, as seems likely according to this particular model, impairment can occur at one of several locations then this may be seen as support for sub-dividing the syndrome accordingly after all. Alternatively, it may be that a different model of reading aloud might be able to explain the varying presentations of the disorder by positing only one lesion or site of damage.

The dual-route model relies not only on the evidence of the possible dissociation of its two routes to validate its structure. It is also dependent on evidence of the existence of the mental lexicon itself, for without such a component the lexical route could not function.

2.3.4 THE MENTAL LEXICON

As written words become familiar to a reader, representation of those words is generally believed to be established in that reader's lexicon. There are two main theories regarding how such a lexicon might be organised, the sequential search model devised by Forster (1976) which is an active processing model and the logogen model as proposed by Morton (1969), which employs a passive processing mechanism by which the words are automatically identified, without any active searching on the part of the reader. The logogen model is generally considered the more influential of the two (Harris & Coltheart, 1986). Indeed, Coltheart (1981) stated that his earlier models of reading aloud were little more than an extended and expanded version of Morton's model. Consequently, it is the logogen model that will be discussed in some detail here.

2.3.4.1 The Logogen Model

Morton (1968) suggested that the lexicon was composed of units, known as logogens, whose role it is to produce the conscious representation of a word. Every word in the lexicon has its own logogen and each logogen has a threshold value at which it becomes activated. Activation is achieved when sufficient information has been accrued to identify the target as a particular word. It is only when activation has occurred that the word can be pronounced.

The structure of the logogen model is such that it is able to provide a satisfactory descriptive explanation for a well-established effect of word reading, the frequency effect. The more frequent a word is in the language the more quickly it can be recognised and/or read aloud (Andrews, 1982). According to the logogen model, as frequent words are often activated their resting level of activation will be higher than that of less frequent words. Consequently, it will take less information and therefore less time for the high frequency words to obtain the sufficient level of activation to reach their recognition threshold.

2.3.4.2 Experimental Support for the Lexicon

The proposed structure of the mental lexicon has also been influenced by a number of experimental findings. The discovery that cross-modal priming did not occur indicated that, as Coltheart (1978) proposed, the lexicon should be divided into separate semantic and phonological units. The further discovery that phonological activation was not a pre-requisite for semantic access led to the further sub-division of the lexical model into orthographic (input), semantic and phonological (output) components.

Originally it was assumed that the input and output lexicons were linked only via the semantic system, a decision presumably made on the basis that the ultimate goal of lexical reading is to activate meaning (Whitney, Berndt & Reggia, 1994) and that there would therefore be no point in the lexical route generating a pronunciation for a word without also producing its meaning.

However, the structure of the lexical route has been further influenced by studies of people with dyslexia who demonstrate "non-semantic reading". The main symptom of this particular syndrome is the retained ability to read aloud words which are no longer understood. A number of patients are described who exhibit this syndrome (Bub, Cancilliere & Kertesz, 1985; Sartori, Masterson & Job, 1987; Schwartz, Saffran & Marin, 1987) and consequently it is evident that words processed through the lexical route do not necessarily automatically activate the semantic system. If the semantic system was always activated then when the semantic system is damaged, in cases such as those described above, incorrect or insufficient information would be passed to the output lexicon and the correct pronunciation would not be achieved. Therefore, it has been proposed that there exists a direct connection between the input and output lexicons which bypasses the semantic system thus providing a satisfactory account for the patient data. Further support for this alteration to the structure of the model comes from numerous reports of people with Alzheimer'sDisease (AD) who retain the ability to read aloud words long after they have ceased to understand them (Friedman, Ferguson, Robinson & Sunderland, 1992).

Coltheart (1981) had been unable to find any evidence from normal subjects that such a route existed and therefore it was created solely because it was necessitated by data from dyslexic patients. Although this is a classic example of how models of reading aloud have been directly affected by evidence from acquired reading disorders, a study by Buchanan and Besner (1993) indicates that Coltheart (1981) was incorrect in his claim that evidence for the existence of this route could not be found in normal subjects. To be read correctly according to the dual-route model, irregular words must be processed by the lexical route. By proving the absence of semantic priming in the processing of such words (priming which would be an inevitable result of their being processed through the semantic system), Buchanan and Besner claim to validate the existence of the direct input-output route.

Despite actually consisting of three possible procedures, the model continues to be referred to as the dual-route model as it is still fundamentally composed of two routes; a lexical route with two sub-divisions and a non-lexical route.

The evidence provided by Buchanan and Besner (1993), and indeed that cited by other studies, is only valid if one accepts the basic premise that the lexical route is designed in the way that has been purported by dual-route theorists, if indeed it exists at all. The risk with studies such as these is that *method, data and theory perpetuate each other through mutual confirmation* (Van Orden, Pennington & Stone, 1990) and thus falsely validate each other's claims. For this reason it is vital to adhere to Coltheart's (1981) stricture that dyslexic syndromes should be described as atheoretically as possible. Otherwise, as he states, the data will be useless if the theory on which it is based should later be proved false.

2.3.5 PHONOLOGICAL DYSLEXIA

One syndrome, phonological dyslexia, was not initially defined atheoretically. Its physical discovery occurred only after its theoretical existence had already been predicted by the dual-route mechanism (Ellis & Young, 1988).

In surface dyslexia, damage is said to have occurred in the lexical route resulting in a difficulty with reading irregular words, whilst the ability to read aloud regular and pseudowords is retained. It was predicted that if the opposite route, the non-lexical route, was disrupted then a different form of dyslexia should occur in which all known words could still be read aloud correctly but in which pseudoword reading would be impaired. This disorder was termed phonological dyslexia. Ellis (1993) states that phonological dyslexia might actually be considered a somewhat *abstruse disorder* (patients can read real words quite well and their inability to read pseudowords is hardly of great functional significance) but justifies the energies spent on investigating it by emphasising its theoretical importance, particularly in relation to its double dissociation with surface dyslexia. Such a disorder certainly appears to strengthen the case for the existence of two separate reading routes and the importance of this double dissociation in supporting the validity of dual-route theory is emphasised by many (Deloche, Andreewsky & Desi, 1982; Coltheart, Langdon & Haller, 1996).

Having initially only been predicted by the theory, the first physical manifestation to be described was a single case study by Beauvois and Derouesne (1979). They concluded that the symptoms of phonological dyslexia are: poor reading of pseudowords compared to real word reading; large numbers of visual and derivational errors; difficulty reading function words; and more successful reading of pseudohomophones e.g. *fome* (foam) than other pseudowords e.g. *bross*.

Humphreys and Evett (1985) state that this disorder seems to be rather more specific than some of its counterparts and that therefore the area of deficit is likely to be more readily identifiable. However, they also suggest that as a phonological dyslexic patient described by Funnell (1983) did not display either poor function word reading or the production of derivational errors, these may not be core symptoms of the syndrome. This latter statement rather contradicts their earlier notion of the exactness of the disorder and suggests that, just as with the other syndromes, variability is almost inevitable. Indeed, Friedman (1988) states that uniform criteria for inclusion of cases into this category of dyslexia have yet to be properly established and expresses doubts about the veracity of the data reported by Funnell (1983).

Funnell (1983) reported the case of WB whom she claimed was a pure phonological dyslexic as he was totally unable to correctly read aloud any pseudowords.

However, her work has been heavily criticised by some who suggest that many of the tasks may not actually test the abilities which she claims to have assessed. Many of the tasks were presented aurally, so the results may reflect the subject's intact auditory-to-phonological recoding processes and not necessarily give any indication of the strength of his reading-specific ability (De Bastiani, Barry & Carreras, 1988) and therefore the results fail to support the double dissociation between the two routes.

Van Orden et al. (1990) suggest that phonological dyslexia is not actually an acquired condition, but rather that it is pre-existing and developmental in nature as some adults without lesions also perform poorly on pseudowords. They argue that this explains why phonological dyslexia is found to be relatively rare compared to the occurrence of surface and deep dyslexia. Although this hypothesis has been supported by others (Skoyles, 1991a), there is no empirical evidence to date to support it. Scant attention has been paid to it by dual-route theorists and a purported link between phonological dyslexia and another acquired dyslexic syndrome, deep dyslexia (discussed in detail in 2.3.6.1), decrease the likelihood of its being considered to have any veracity. Coltheart's (1981) warning should however be remembered as the existence of this acquired syndrome was predicted solely on the premises of dual-route theory.

2.3.6 DEEP DYSLEXIA

Deep dyslexia is characterised by a predominance of semantic paralexias (Ellis, 1993). Other subsidiary symptoms are the production of derivational errors, more success with content than function words, poor pseudoword reading and multi-derivational errors (Friedman, 1988). Both Coltheart (1981) and Friedman (1988) assert that the presence of semantic paralexias guarantees that a patient will display all the other symptoms associated with deep dyslexia.

Initially, it was suggested that the variety of symptoms of deep dyslexia could not be explained by the model and that therefore perhaps reading in the presence of deep dyslexia was accomplished by a system in the right hemisphere. If this were the case, the study of deep dyslexia would be of little use as a tool for investigating the nature of the normal reading system (Coltheart, 1981). Whilst it would be a severe omission not to make reference to this theory, a detailed description of the investigations themselves is somewhat extraneous to this discussion given that the right hemisphere theory is not widely accepted (Harley, 1995) and also due to the aforementioned emerging links between deep and phonological dyslexia.

2.3.6.1 The Continuum of Deep and Phonological Dyslexia

Whilst insisting that deep and phonological dyslexia must be distinguished from each other, Coltheart (1981) recognised that they shared some similar features – namely the dissociation between word and non-word reading. This similarity was investigated by Glosser and Friedman (1990), who proposed that the two syndromes actually lay on a continuum of disorder. They investigated the case of patient GR who 1 month post-onset from a closed head injury displayed typical symptoms of deep dyslexia: 11% of his errors were semantic and he had a score of only 1/20 on pseudoword reading. On being re-tested 14 months later, GR still had difficulty with pseudoword reading, but displayed no semantic paralexias and thus appeared to be affected by phonological dyslexia.

Similarly, Glosser and Friedman also report a study of patient DV, who at 4 months post-onset from a CVA was unable to read pseudowords and 10% of his errors were semantic paralexias. Re-testing some three years later showed a marked improvement in semantic errors to only 2% and some small improvement in pseudoword reading. Glosser and Friedman conclude that in both cases deep dyslexia developed into phonological dyslexia thus supporting their hypothesis of a continuum of disorder.

Marshall and Newcombe (1973) described the performance of two patients, GR and KU. GR was recorded as making errors that were mainly semantic substitutions, although derivational and visual errors were also a common feature of his reading. KU made similarly high numbers of derivational and visual errors, but very few semantic errors. Whilst acknowledging that the relative degree of semantic impairment differed greatly in the two cases, Marshall and Newcombe classified both patients as having the same general type of dyslexia, deep dyslexia. In fact, based on the information available about the cases, KU would now almost certainly be diagnosed as having phonological dyslexia. At the time that the original classification was made phonological dyslexia was not a recognised disorder and the investigators had to assign the patient to the category which they considered to be the best fit. The fact that the category which they chose was deep dyslexia suggests that they may unknowingly have been supporting the existence of that same continuum between deep and phonological dyslexia.

Glosser and Friedman (1990) propose that in deep dyslexia the impairment in pseudoword reading as well as the derivational errors can be accounted for by disruption in the access to, processing in, or output from the phonological lexicon (as in phonological dyslexia), but that the occurrence of semantic paralexias requires a second lesion site in the semantic processing mechanism. This suggestion fails to explain why such damage might resolve spontaneously, thus allowing deep dyslexia to evolve into its phonological counterpart. However, both the patients described by Glosser and Friedman were described as suffering from deep dyslexia whilst still less than one year post-onset of their initial traumas. On this evidence, it could be hypothesised that deep dyslexia occurs only initially and that the variety of symptoms is not due to a multitude of possible lesion sites, but rather to neurological instability. This suggestion would imply that the underlying disorder is phonological dyslexia.

2.3.7 RELATIONSHIP OF THE TWO ROUTES

Description of the model so far has been confined to an explanation of its structure and the individual modules within that structure and how breakdown(s) might occur in either route. In assuming the existence of two independent routes we must not only acknowledge the possibility that the operation of one route in isolation may be different from its operation in its normal context of the other route (Patterson, 1981) but also consider the question of how they function in relation to each other under normal circumstances. The operating mechanisms of any model must be able to satisfactorily explain:

- Why real words are pronounced more quickly than pseudowords
- How skilled readers produce the correct pronunciation for familiar irregular words
- Why low frequency regular words are named more quickly than low frequency irregular words

As the role of the visual analysis system is thought to be to simply recognise and encode letter position (Ellis & Young, 1988) it is unreasonable to suggest that it might be able to identify an input string as a regular or irregular word or indeed as a non-word letter string. Therefore, the reader has no means of determining which of the two routes the encoded information should be passed to and so it seems that both routes must receive the information (Henderson, 1985).

It has been proposed that a *race* occurs between the two routes to produce an output for any given letter string (Henderson, 1982). Both routes receive the output of the visual analysis system at the same time, but because of its direct look-up mechanism the lexical route will be much faster and will therefore usually "win". Consequently, all words known to the reader will be processed more quickly than any pseudowords, the pronunciation of which would have to be constructed via the non-lexical route as no pseudoword pronunciations are stored in the lexicon. This would also explain why irregular words are named correctly, the direct lexical look-up mechanism functions more quickly than the assembled pronunciation method of the non-lexical route so, assuming that the irregular word is in the lexicon, the correct addressed pronunciation will be identified more rapidly than an incorrect one can be assembled.

In the case of less frequent words the direct route will take longer than usual, as is explained by the construction of the lexical access mechanism (c.f. 2.3.4.1). For regular words this will not be so pertinent as both routes will produce the same pronunciation anyway. However, it has greater implications for irregular words as the two routes will produce conflicting pronunciations. It is argued that this conflict is responsible for the increased length of time it takes for infrequent irregular words to be produced compared with their frequency-matched regular counterparts. The fact that, in normal readers at least, low frequency irregular words are generally given the correct pronunciation has been explained by the suggestion that the lexical route is the dominant route and that its output will override that of the non-lexical route when any conflict occurs.

By proposing that the lexical route has smaller resource requirements than the non-lexical GPC route, Paap and Noel (1991) strengthen the case for the proposed greater speed of the lexical route. Lexical processing is assumed to be passive, (c.f. 2.3.4) whereas the GPC route has to actively construct a pronunciation and therefore requires more resources. It is argued that the routes also differ in capacity requirements, the lexical route appears to be more automatic whilst the GPC route requires more conscious control. Not only do their differing needs (in terms of resources and capacity) explain why the two routes appear to process stimuli at different rates, but Paap and Noel also claim that their explanation provides further evidence supporting the existence of two distinct routes. They claim that the two routes can be clearly dissociated due to their different attentional requirements. By default, this position also provides further support for viewing the logogen model rather than the serial search model as the correct explanation of the functioning of the lexicon - the logogen model, being passive, will reduce the resource requirements of the lexical routine, whereas the active serial search model would increase those requirements.

There are no real means by which to investigate the veracity of the race hypothesis, it is in fact a supposition based on the need to explain the fact that most readers read aloud most irregular words correctly most of the time. It is therefore a satisfactory explanation in that it accounts for the evidence, but there may be any number of other equally plausible explanations.

There is a considerable body of evidence that questions the separate existence of the two routes. Humphreys and Evett (1985) state that if the two routes are truly separate then either route could be selectively impaired leaving the other completely intact, yet they conclude that all reported cases show some level of damage to both routes. Consequently, they suggest that it is impossible to test either route satisfactorily and conclude therefore that there can be no solid evidence that the two routes exist, much less that they are actually totally separate.

Glushko (1979) established that pseudoword processing was not performed without some input of lexical knowledge when he demonstrated that pseudowords created from exception words e.g. *tave* (from *have*) took longer to pronounce than those created from regular words e.g. *taze* (from *haze*). These findings were corroborated by Rosson (1983) who found that pseudoword pronunciation could be primed by prior presentation of an orthographically similar real word e.g. pronunciation of *louch* altered depending on whether *couch* or *touch* was used as a prime. Additionally, as Funnell (1983) points out, models which consider the two routes to be totally independent are failing to take into account the ability of the reader to add new words to the mental lexicon, a process which must surely require information to be passed from one route to the other.

Paap and Noel (1991) are also convinced that the two routes, whilst separate, do not function independently and this conviction is supported by the findings of Buchanan, Hildebrandt and Mackinnon (1994) who report the case of a patient with deep dyslexia who showed implicit phonological awareness of pseudowords. Although he was unable to read pseudowords aloud, in a visual lexical decision task he took longer to reject phonological pseudohomophones than the control items which were orthographically legal pseudowords. This effect would suggest that the patient was sensitive to pseudoword phonology, even though strict dual-route accounts of deep dyslexia would propose that not only had the non-lexical pathway been totally abolished, but that lexical phonology could not influence pseudoword processing. These findings suggest that there may be some sharing of information between the two routes.

Monsell, Patterson, Graham, Hughes and Milroy (1992) do suggest an alternative to the race model which might account for how the two routes interact. They propose that the output of the two routes is continuously pooled until a phonological representation is generated that is sufficient for articulation to occur. Again, the regularity effect is explained by the time taken to resolve the conflicting pronunciation of irregular words generated by the two routes and slower pseudoword production is accounted for by the dependency on the non-lexical route alone. However, as the authors themselves admit, they can provide no specification as to what might be considered a "sufficient" phonological representation, or indeed at what point along the routes pooling occurs.

2.3.8 PROBLEMS FOR DUAL-ROUTE THEORY

It is the lack of specificity of the manner in which the model actually works that is one of its most fundamental flaws. The model is used to demonstrate that a particular function is performed by a certain box or arrow, without explaining exactly how it works (Patterson, 1990). Details as to how the GPC route functions appear to be particularly lacking and the grapheme units that it uses are not always considered to be the most appropriate to the English language (Treiman, Fowler, Gross, Berch & Wetherston,1995).

The findings of Glushko (1979) suggest that the single level processing view which considers graphemes to be the only relevant functional unit is inadequate. He established that components larger than the grapheme, namely the word body (vowel + final consonant) were implicated in the processing of words as well as pseudowords. In an attempt to account for these findings in terms of a dual-route theory of processing, Shallice, Warrington and McCarthy (1983) devised the multiple levels model. This model proposes that the GPC route works on seven levels of processing unit rather than the more traditional one. Whereas GPC concentrates only on the grapheme level, this model considers initial consonant clusters, vowels, syllable-final consonant, initial cluster and vowel, rimes, syllables and morphemes. Thus the two route structure is maintained and Glushko's findings can be accounted for, as units larger than the grapheme can be utilised in both word and pseudoword processing.

The two different routes in the multiple-levels model, now labelled the whole word and synthesised pronunciation routes, are claimed to act in parallel and combine their outputs to arrive at an integrated interpretation of the input. Presumably this is achieved in a similar fashion to the unspecified manner of the mechanism proposed by Monsell et al. (1992). This system has the disadvantage that the increase in the number of functional units to be stored leads to a great increase in the amount of memory needed to store them (Norris, 1994) and presumably there is also considerable conflict at the point where the outputs combine to form a pronunciation. No indication is given as to how this conflict is resolved or whether the units are assumed to follow a hierarchical order of processing, although Shallice and McCarthy (1985) do suggest that the higher levels (larger units) can be used more rapidly.

Newcombe and Marshall (1985) suggest that the input string might be segmented initially on a left-to-right basis with successive letters over-ruling earlier parses. This would not only overcome the issue of conflict, but would also resolve the question of how the model knows at which unit level to segment a particular word by implying that it segments each input at all possible levels. However, they suggest that such multi-segmentation might prove rather time consuming and a mechanism by which the largest units are considered first, followed by progressively smaller units when necessary, might be a more economical approach in terms of both time and processing capacity. Much of the investigation of the multiple levels model has concentrated on parsing polysyllabic words, rather than the monosyllables and pseudowords which are the typical investigative stimuli of such models. It may be that such an elaborate arrangement of unit levels is not necessarily invoked for the reading of less complex stimuli.

Few studies of people with dyslexia have applied the multiple levels model, but Kay and Lesser (1985) supported its implementation, claiming it provided a better fit for their data than the original GPC route of the dual-route model. Their measurement of irregular word reading ability was obtained using the National Adult Reading Test (NART) (Nelson, 1982), which uses many polysyllabic words and may therefore be a better test of the model than simple monosyllabic stimuli. However, the patient produced very few real word errors and many neologisms, which do not provide support for any particular model, but rather imply that the patient may have had difficulties in many areas of processing and/or production.

Derouesne and Beauvois (1985) report a phonological dyslexic patient, LB who was able to read pseudohomophones e.g. *rist*, better than other pseudowords which were orthographically legal but had no phonological resemblance to real words e.g. *brone*. They suggest that this was achieved because LB was able to retrieve the phonological form of the real word which shared the phonology of the pseudohomophone, thus there was no need to rely on phonological information from the (damaged) GPC route to construct the whole phonological form of the pseudohomophone. They claim that not only does this support the existence of a phonemic stage in the non-lexical reading process, but it also proves that subsyllabic units are functional units of reading, thus questioning dual-route reliance on the grapheme and supporting the multiple levels model.

Shallice and McCarthy (1985) describe patient HTR whose performance on irregular word reading was considerably worse than that on regular word reading. They conclude that his error patterns present a problem for the standard dual-route model as it would predict that all irregular words should be equally problematic in a patient with a damaged non-lexical route. Further investigation found that the critical unit for HTR was the subsyllabic rime unit (vowel and consonant cluster), thus supporting, according to Shallice and McCarthy, the multiple levels model. They claim that the multiple levels model can explain the occurrence of semantic dyslexia in terms of a partially damaged phonological route in which the amount of information transmitted is sufficient to allow effective discrimination between subsyllabic units but not between morphemes.

Patterson and Morton (1985) proposed a rather less complex model, the modified standard model. The non-lexical or orthography-to-phonology correspondence (OPC) route deals with only two sets of units, graphemes and rimes, although they do not specify why these two units in particular were chosen. However, they do recognise the need to specify a decision rule between the two subsystems and consequently they propose that the OPC system is over-ruled by that of the GPC in 70% of cases. No explanation is given as to how or why they chose such a cut-off point, nor as to which cases would fall outwith the 70% margin.

Systems such as these are simply dual-route systems with more complex non-lexical processing routes than the original model. However, as Monsell et al (1992) point out, if spelling-to-sound correspondences are simultaneously computed at multiple levels there seems to be no rationale for assuming that the whole word level is sectioned off in a separate route. Indeed, Coltheart (1981) acknowledges that there may in fact not be two routes to pronunciation, but maintains that the double dissociation of surface and phonological dyslexia makes it difficult to envisage how a single mechanism might function in such a way as to make these phenomena explicable.

The only other established reason for arguing in favour of the two route approach has been the existence of irregular words. The need to identify a manner in which they could be successfully pronounced was the basis for the construction of the lexical route (Van Orden et al., 1990). However, their existence is not so straightforward as it might initially appear (Venezky, 1967), for as Friedman (1988) states, some words may be classified as regular or irregular depending upon the criteria selected. The findings of Glushko (1979) amongst others have established that more types of relationship must be considered than the simple regular-irregular dichotomy. If the functional applicability of the irregular classification is disputed then it follows that the value of dual-route theory must also be questioned. A more thorough discussion of the issues surrounding word classification is presented later in this chapter (2.9).

2.3.9 CLINICAL APPLICATIONS OF DUAL-ROUTE THEORY

As part of a comprehensive cognitive neuropsychological model, the dual-route model of reading aloud is now widely used in clinical practice with adults with acquired neurological disorders. The principles of the model can be tested by two assessments of reading aloud. The National Adult Reading Test (NART) was referred to in an earlier section (2.3.8). It was designed for the assessment of adults with a possible diagnosis of dementia and not specifically for people with dysphasia. It does not focus on dual-route theory, but it is composed entirely of irregular stimuli and as such is often implemented as a test of lexical route functioning. However, it contains only a limited number of stimuli and many of these are not in common usage. Further complementary assessments would also be necessary in order to test the functioning of the non-lexical route.

The Psycholinguistic Assessment of Language Processing in Aphasia (PALPA) (Kay, Lesser & Coltheart, 1992) is a comprehensive assessment battery. It allows many areas of language functioning to be investigated using a wide variety of tasks e.g. visual lexical decision, word-picture matching. The section on reading aloud distinguishes words according to their regularity, letter length and, in some instances, frequency. The PALPA is highly regarded as a clinical tool, enabling levels of breakdown to be identified within the dual-route model in preparation for appropriate remediation. However, as its focus is the dual-route model of reading aloud, it is not a suitable tool for testing the success of other theoretical approaches to reading aloud.

2.3.10 SUMMARY OF DUAL-ROUTE THEORY

In summary, whilst dual-route theory has much to commend it, not least that it brought cognitive neuropsychological modelling into a clinical perspective, there are many strong arguments against it. It still retains some supporters of its structure and choice of functional unit (Whitney, Berndt & Reggia, 1994), but as the evidence already discussed shows, its explication is unsatisfactory in many respects. There is no clear argument for the separation of the two routes and indeed, if those who support the belief that irregularity is not central to the structure of the language are correct, there is in fact no need for the two separate routes to exist at all.

2.4 ANALOGY THEORY

A number of other models have been proposed which differ quite radically from the premises of dual-route theory. The first of these was the analogy model produced by Glushko (1981) in response to his earlier findings that lexical knowledge influenced pseudoword processing and that units larger than graphemes appeared to play a central role in the production of both words and pseudowords (Glushko, 1979). The model was based on his assertion that words were not regular or irregular in their own right, but only in the context of other orthographically similar words. Dividing words into categories according to their pronunciation and that of their orthographic body neighbours (words with the same rime/body, vowel and final consonants), Glushko recognised two distinct groups. Consistent words, such as *mill*, *pill*, *hill*, where all words with the same body have a pronunciation that rhymes and inconsistent words where there is some conflict in the pronunciation of body neighbours e.g. *hint*, *mint*, *tint*, versus *pint*. Inconsistent words were, according to Glushko's findings, pronounced significantly more slowly than consistent words.

2.4.1 GLUSHKO'S MODEL

Based on his findings, Glushko proposed that phonological activation was of a single type, that all letter strings are recognised and pronounced by the same knowledge activated in the same way, rather than by two separate types of knowledge (lexical versus non-lexical route) using different applications (lexical look-up versus GPC application). According to this model, as letters in the target word are identified, an entire neighbourhood of words that share the same orthographic features is activated and, in the case of unknown words or pseudowords, a response is generated by synthesizing information from the many partially activated phonological representations.

The analogy model provides satisfactory explanations of certain effects of normal word processing. It explains the frequency effect by proposing that the more often a word is activated the more likely it is that there will be a whole word representation of it in the storage component of the module, (it cannot properly be referred to as a lexicon as it contains structures other than real words). The representation can then simply be activated without time having to be spent synthesising a production. The increased time it takes to produce pseudowords over real words is similarly explained. Pseudowords, having no whole-word representation, require their pronunciation to be synthesised. Presumably, although it is not stated overtly, those words with inconsistent pronunciations take longer to generate a response due to the conflict that occurs between possible pronunciations, however the actual mechanisms by which this might operate are not specified by Glushko.

The general feeling with regard to the viability of analogy theory appears to be that whilst there is considerable evidence to support the psychological reality of analogy (i.e. the pronunciation and categorisation of words based on the relative consistency of their relationship with other similarly spelled words) there is a concerning lack of detail about the actual structure and workings of the model (Henderson, 1982; Norris, 1986).

Coltheart (1981) objects to the principle of analogy theory on the basis that people with phonological dyslexia are able to read real but not pseudowords and he disputes that this could occur if both were read by the same mechanism. De Bastiani et al. (1988) disagree. They state that a partial impairment to the assembly function would mean that only pseudoword reading need be greatly affected as real word pronunciation can be obtained whole. They conclude that the separation of word and pseudoword reading in phonological dyslexia should not necessarily be taken to support the view that the two are functionally independent. However it should be noted that the explanation that they use is not so very dissimilar from that of dual-route.

Friedman, Ferguson, Robinson and Sunderland (1992) found evidence supporting analogy theory in a study of people with Alzheimer's Disease (AD). People with AD are generally able to read aloud regular and irregular words in the absence of comprehension of those words and are also able to read pseudowords. Friedman et al. posited that it was unlikely that people with severe AD were able to apply a complex set of GPC rules in order to achieve this. They suggested that if subjects used an analogous method of word pronunciation then they would have most difficulty with a set of pseudowords which did not have any body neighbours, non-analogous pseudowords (NAPW) e.g. *kurj*. They found that both the AD subjects and the control group performed less well on the NAPW stimuli and that the AD subjects produced irregular pronunciations with the same frequency as normal controls. Thus the findings not only suggest that both groups decode pseudowords in a similar fashion, but they also support analogy theory.

Given its limitations, the value of analogy theory lies not in the concept per se, but rather in the opening it provided to explore alternatives to dual-route theory by breaking away from the regular-irregular dichotomy and its corresponding need for lexical and non-lexical processing routes.

2.5 SINGLE-ROUTE THEORIES

The influence of the multiple levels type models which questioned the need for a separate lexical route combined with Glushko's (1979) findings enabled theorists to postulate a radical alternative to dual-route theory - the existence of a single route in reading. Advances in both technology and mathematical theory allowed models of this theory to be implemented on computers. It was then possible to provide a simulated performance of how a process might occur. This overcame the limitations of previous representations which stated that a certain function was carried out by a particular module without, on the whole, providing any satisfactory explanation of how that function might actually be performed (Patterson, 1990). The type of architecture which these models employed was a connectionist one.

2.5.1 CONNECTIONIST MODELLING

Reading was one of the first areas of language processing to be tackled by connectionist modellers and consequently such models of reading aloud are some of the most advanced of their type. Connectionist architectures are considerably different to their more traditional modular counterparts.

2.5.1.1 Functional Architecture

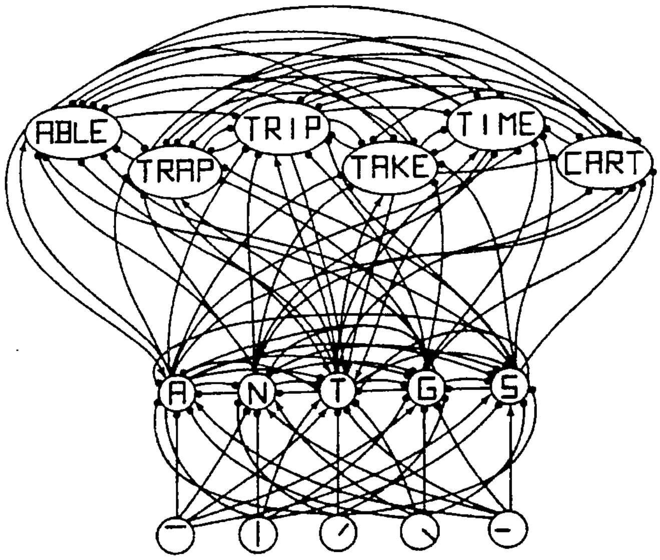
In considering the concepts central to connectionism, Harley (1995) identified two of the most striking differences between this and the more traditional approaches. The first is that in connectionist models all the many processing units are interconnected rather than being linked in the strict hierarchical order seen in the dual-route model. The second is that connectionist models are active, rather than passive, processing models with energy or activation being spread around the network via the connections which link the individual units.

Inherent in their creation is the fact that these models are able to learn, they do not simply contain static representations of knowledge, such as those found in the mental lexicon of the dual-route model, but rather the processing of any new input is influenced by the experience gained from the processing of all previous inputs. When a model is formulated no rules are explicitly programmed into the network, instead the network creates its own rule-like behaviour based on the words on which it is trained. It is given details of both the orthography and phonology of all the words in the training set and it is on this information that it devises its own implicit rules. When training is completed, the model can be tested by giving it an input (in the form of a word's orthography) for which it will then produce an output (in the form of a phonological representation). The model's rules are continually adapted to account for the vagaries of each new input. Therefore, unlike the GPC route of dual-route models, these models are not rule-based but they are rule-following (Sejnowski and Rosenberg, 1986).

2.5.1.2 Interactive Activation Model (IA)

In order to explain effectively such a conceptually complex system it seems appropriate to briefly describe one of the earliest connectionist models of reading aloud, the Interactive Activation Model (IA) (McClelland & Rumelhart, 1981). Not only will this serve as a basic introduction to the practical application of connectionist principles, but because of its particular components it will also enable the charting of the development of such models from their origins in the dual-route model. Although disparate in structure, the modular and connectionist models of reading aloud do, in fact, have much in common.

Figure 2.2: The Interactive-Activation Model



From McClelland and Rumelhart (1981, p.380)

This early model (see Figure 2.2) proposed that a series of visual-feature units are connected to letter units which are in turn connected to word units. All the units are connected to all the other units in the adjacent levels of the model and each unit has a level of activation that can spread along its connections. The resting level of activation of each unit is set proportional to the frequency of that unit, in much the same way as threshold values are set in the logogen model. The rate at which the activation spreads is essentially controlled by weights on the connections. Weights may be positive or negative such that a particular input will cause a unit to be excited or inhibited depending on the sign of the weight which drives it (McClelland, 1989).

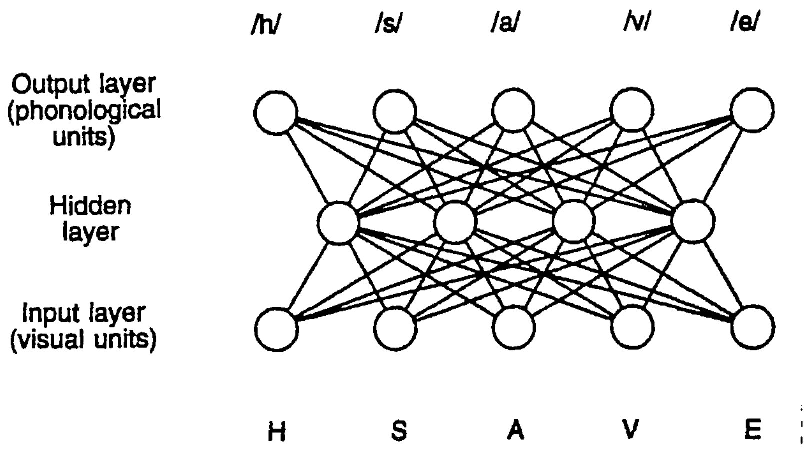
Even in this very simple form, the model is able to explain many of the known processing effects. The frequency effect occurs in much the same way as in the dual-route model, with higher frequency words having a higher resting level of activation allowing them to be activated more rapidly than less frequent words. It is suggested that the real word superiority effect can be explained because activation occurs in a top-down manner from word to letter units. This feature increases the speed at which real word processing occurs compared with pseudoword identification because real words can be identified at the word level and have coherent word-to-letter level activation, whereas pseudowords must be processed at the lower, letter level.

The regularity effect is explained by the sign of connection weights causing a *gang effect* to occur. Members of consistent neighbourhood gangs become highly activated more quickly due to all the positive support they receive from similar units, whereas words that do not have the positive support (words with pronunciation at odds to most of their neighbours) actually suffer from the inhibitive weighting of connections between themselves and their phonological enemies.

This model exemplifies connectionism, or parallel distributed processing (PDP), in its most basic localist form. By placing individual letter detectors at each letter position in the input string, the model is able to carry out spatially parallel processing by processing different letters in the string at the same time. However, this is only achieved by maintaining a whole alphabet of letter detectors at each position in the field. Humphreys, Evett and Quinlan (1990) showed that such position priming does not in fact occur and consequently that the inclusion of such units is unnecessary, which is fortunate given that a large vocabulary would require an unrealistic number of units and connections. It may be that this notion of letter specific detectors was simply an artefact of the influence of dual-route models where inclusion of a specific visual analysis system was vital to the operation. Subsequent single-route models, as will be shown in the following discussion, have moved further away from the structures of the traditional models.

2.5.1.3 Seidenberg-McClelland 1989 Model (SM89)

Figure 2.3: The SM89 Model



From Harley (1995, p.122)

The distributed, developmental model of word naming (Seidenberg & McClelland, 1989) is constructed along considerably less conventional lines than the IA model. The goal in developing the model was to produce a minimal model of lexical processing in which as much as possible was left to the mechanisms of learning rather than being implicit in the structure itself. Learning involves modifying the weights through experience in reading and pronouncing words. The simplified model consists of a layer of 460 phonological units linked to a layer of 400 orthographic units via a layer of 200 hidden units. Knowledge is represented in terms of the weights on connections.

As has been previously described, dual-route models store word knowledge as a static copy of a pattern in a storage module or lexicon. In contrast, connectionist models do not store the pattern per se, rather the connection strengths between patterns are stored and these allow the patterns to be re-created as and when they are activated. Knowledge of patterns is distributed over connections among a large number of processing units. The model does not entail a look-up mechanism because it does not contain a lexicon, instead it replaces both the lexicon and the GPC set of pronunciation rules by a single mechanism that learns to process all types of words and pseudowords (Seidenberg & McClelland, 1989). Words and pseudowords are distinguished only by functional properties of the system, the way in which particular patterns of activity interact. Within the single-route models, words are not defined solely in terms of their individual regular or irregular spelling-to-sound correspondences. Instead, it is assumed that the phonology of other words with similar spelling patterns (neighbours) will influence the production of a target word. Whether that influence is positive or negative in terms of the weights on the connections depends on whether the pronunciation of the neighbours supports or conflicts with the pronunciation of the target. Thus, a major advantage of the connectionist approach is that it provides a more natural account of graded effects of spelling-sound consistency among words, such as those suggested by Glushko

(1979), and how this interacts with frequency (Plaut & McClelland, 1993), rather than the all or nothing demands of dual-route theory.

2.5.2 PERFORMANCE OF SINGLE-ROUTE MODELS

Coltheart, Curtis, Atkins and Haller (1993) identified several aspects of reading which they would expect a successful model of the reading aloud process to address:

- The reading of exception words
- The reading of pseudowords
- The occurrence of surface dyslexia
- The occurrence of phonological dyslexia
- The performance of the visual lexical decision

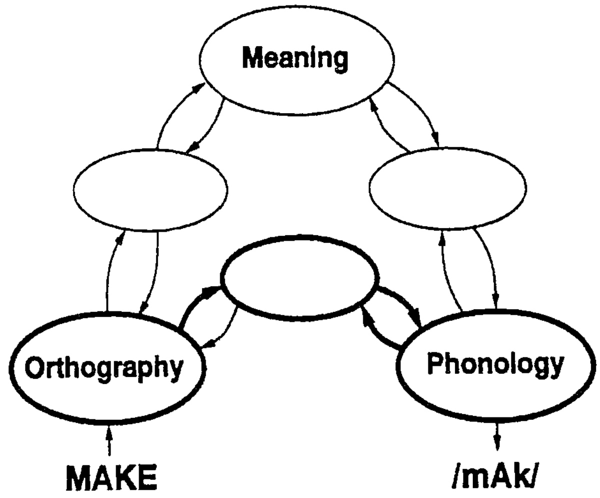
At the time at which these criteria were established, Coltheart et al. (1993) intended them as a criticism of single-route models as such models were unable to satisfy them all. However, further development of both the structure and functioning of these models has enabled them to provide acceptable explanations for most of them. A discussion of performance of the visual lexical decision task appears in Chapter Four.

2.5.3 THE READING OF EXCEPTION WORDS

Although it does not possess a lexicon, the model is still able to explain the fact that performance is poorer on low-frequency exception words. These words are neither sufficiently common to have much effect on the adaptive learning mechanism of the network, nor are they consistent enough to benefit from the shared structures created by their orthographic neighbours (Patterson, Plaut, McClelland, Seidenberg, Behrmann & Hodges, 1996). Therefore, they take longer to process and are considerably more vulnerable to the effects of a damaged system than their heavily supported consistent counterparts.

The involvement of semantics is likely to be particularly important in the reading of low-frequency exception words which will have poor O-P representations. The relationship between orthography and phonology is one which the computer can understand and calculate, however models such as this cannot absorb and store semantic information with the same ease as there is no such systematic relationship between the surface forms of (monomorphemic) words and their meanings (Plaut, 1996a). As far as the computer is concerned, words are nothing more than abstract entities so semantic information cannot be utilised in the same manner as it is by human readers. Although it is easy for modellers to include a semantic component, it is less easy for them to either explain how it works or indeed induce the computer to use it when processing inputs. In terms of finding a technical solution to this problem, modellers have devised a means by which they can approximate the contribution which meaning makes to the identification of a word. It is then possible to translate the value of this contribution into an extra source of input to the phoneme units. This additional input increases the speed of activation of the phoneme units leading to a subsequent increase in the speed of word identification. Whilst this solution may have technical validity in the sense that word identification can be said to be quicker as a direct result of semantic involvement, it is one which has to be orchestrated by a force outside of the model itself. This is not an aspect of word processing which the model is able to learn to perform for itself.

Figure 2.4: The SM89 Model with a Semantic Component



Adapted from Plaut, McClelland, Seidenberg & Patterson (1995, p.4)

On a superficial level, the model shown in Figure 2.4 now looks similar to a very simple version of the dual-route model. The model's creators state that this is not the case and emphasize that although the model now contains a phonological and semantic pathway they operate along very different principles and in very different ways to the pathways of dual-route models. The biggest difference is that the pathways do not operate independently or separately in any way, in fact it is only the representation of them on paper that makes them appear as separate pathways at all when really they are better viewed as a multi-layered inter-dependent network.

2.5.4 THE READING OF PSEUDOWORDS

The single-route model has been strongly criticised by Besner, Twilley, McCann & Seergobin (1990) for failing to reproduce certain effects adequately. Most particularly they claimed that it performed at a level considerably below that demonstrated by normal human subjects in the reading of pseudowords. Quinlan (1995) felt that this poor performance on pseudowords was indicative of the fact that the model was very poor at generalising from the initial training set to letter strings which it had not previously seen before. This criticism is in fact far more serious than simply challenging the model's ability to perform pseudoword reading. Were Quinlan's claims to be proved correct they would destroy the whole premise on which the model is based. If the model cannot generalise what it has learned it seems that the process of learning cannot be ongoing and yet according to its creators the model learns based on the relationships between the words it encounters. If the model is truly unable to generalise then nor can it truly be said to learn. Plaut et al. (1996) could not deny the criticisms, but retaliated by claiming that the limited set of words to which the model was exposed during its training period was insufficient to enable it to deal adequately with pseudoword strings. Enlarging the training set and adapting the design of the model enabled it to achieve a level of pseudoword reading within normal limits. Skoyles (1991a) states that PDP pseudoword reading skills are important even if they are not as good as human skills because they indicate that we cannot continue to assume that people use an independent GPC route every time they read a pseudoword. In fact, connectionism shows that pseudoword reading can be done purely by processes trained on real words without the use of specific grapheme-to-phoneme translation processes (Skoyles, 1991b).

2.5.5. THE OCCURRENCE OF SURFACE DYSLEXIA

Surface dyslexia is said to involve reading primarily via the partially impaired phonological pathway due to a damaged semantic pathway (Plaut et al. 1995). However, there is an alternative explanation based on a division of labour hypothesis. Plaut et al. argued that surface dyslexia reflects the behaviour of an undamaged but isolated phonological pathway that has learned to depend on support from semantics. This not only explains the occurrence of the disorder but also supports a view of normal reading in which there is a division of labour between the two pathways such that neither pathway alone is completely competent and that the two must work together to support skilled word reading. This would also explain why pure forms of the disorder are not reported - the whole network must be intact for pronunciation to be successful.

It does appear that the deterioration of word meaning may be the cause of surface dyslexia. Patterson and Hodges (1992) report six case studies which illustrate a range of levels of comprehension deficit. Regular word reading appeared to be largely unimpaired in all the cases, but the ability to read aloud exception words was significantly affected by word frequency and also seemed to be directly related to the severity of the comprehension loss. Patterson and Hodges conclude that a basic ability to derive phonology from orthography has been retained as regular words are still read efficiently, so they conclude that there are three possible ways to explain why the exception word deficit occurs:

a) They propose that the normal translation of orthography to phonology for exception words is partly mediated by word meaning. They acknowledge that the SM89 model shows it is possible to deal with both regular and exception words by means of only the orthographic-to-phonological route but suggest that it is likely that word meaning is an important factor in word pronunciation for human readers. Therefore, it is suggested that the processing of low frequency exception words is conducted by the semantic route so that the direct orthography-to-phonology route is able to function more efficiently. This appears to be somewhat implausible as an option as it seems to suggest the existence of a lexicon solely for the storage of low frequency exception words. Although it could be that the weights on the connections for such words require greater input from the semantic units than regular words which are more straightforward in their orthography-to-phonology translation, the authors conclude that this explanation lacks psychological reality as skilled adult readers show no evidence of reading low frequency exception words via semantics.

b) An explanation using the multiple levels model (Shallice & Warrington, 1983) might be that the absence of semantics is irrelevant to word reading. The exception word deficit might be due to progressive brain disease causing increasing cognitive dysfunction which would affect orthography-to-phonology translation at the highest level of unit classification first, i.e. whole word level. Consequently, exception words which rely on whole word retrieval would be affected first.

c) The preferred explanation of Patterson and Hodges (1992) is that although the actual translation from orthography-to-phonology does not require semantic input, normal interaction with the semantic system is vital for the integrity of lexical representations. They suggest that meaning is the factor that holds the phonological elements of a word together and that the deterioration of semantics will therefore mean that words are no longer read as whole units. They suggest that even though the various phonological elements of words could then be reblended to construct the whole word pronunciation that the fragmented representations will have heightened thresholds and will therefore be harder to reproduce. Therefore, in the absence of meaning, the translation of word "pieces" from orthography-to-phonology will dominate over whole word translation.

This latter account predicts that the deterioration of word meaning will result in surface dyslexia and supports the theory of Plaut et al. (1995).

Further support for this explanation of the symptoms of surface dyslexia was provided by a study of deep dysphasia, a compound of disorders including surface dyslexia. Valdois, Carbonnel, Davoid, Rousset and Pellat (1995) argued that degradation of the O-P association within the single-route triangle could explain the whole disorder, whereas the dual-route model would have to postulate multiple functional lesions to account for all the difficulties found in deep dysphasic patients.

2.5.6 THE OCCURRENCE OF PHONOLOGICAL DYSLEXIA

Plaut et al. (1995) claim that phonological dyslexia also has a natural explanation within the framework of the SM89 model. Selective damage to the phonological pathway would demand that reading occurs largely by the semantic pathway. This pathway is said to be used to pronounce words, but will be unable to provide much support for pseudoword pronunciation as such letter strings have no semantic representations. Hinton and Shallice (1991) developed the model to account for this by detailing a connectionist network that develops attractors for word meanings, so even when the O-P route is damaged the attractors will stay intact.

This explanation bears a resemblance to the method in which the dual-route models function. However, according to the dual-route model, phonological dyslexia is the result of an impairment to the non-lexical system, so reading of real words should not be in any way affected. The fact that real word reading is usually also affected and that some people with dysphasia exhibit particular difficulties with functors and grammatical morphemes can only be explained in dual-route terms as arising from multiple lesions. Single-route models are able to explain the syndrome as being caused by only one lesion. Damage to the O-P route in the single-route model will lead to reliance on the semantic pathway where it is claimed that words with less densely inter-related patterns of activity are less accessible, therefore those people relying on the semantic system are more likely to make function word reading errors when the O-P route is damaged.

2.5.6.1 Two Types of Phonological Dyslexia

Friedman (1995) suggests that there may be two types of phonological dyslexia. Phonological dyslexia is usually defined as a difficulty reading pseudowords compared to real words and a particular difficulty with the reading of functors. Friedman argues that some of the reported cases, which are described as showing the decline in pseudoword reading ability usually seen in phonological dyslexia, do not manifest the associated specific difficulty with the reading aloud of functors and morphemes. She proposes that such general real word reading difficulties can be explained by a general impairment of phonological activation. When the ability to activate phonology is disturbed, the better established patterns (i.e. those of more frequent words) will be better preserved so that although reading of both words and pseudowords will be affected, performance on pseudowords will be noticeably worse. There will be no specific impairment of function word reading, as all words will be similarly affected according only to their frequency and not to their class.

Friedman proposed that studying the results of a pseudoword repetition task would enable her to investigate the hypothesised existence of the two types of phonological dyslexia. She argued that those people with poor pseudoword repetition skills would have a general phonological impairment and would therefore show general word reading difficulties, whereas those with good repetition skills would be the ones who had relative difficulty with functors. Her findings supported this theory. In fact, the results of the study not only supported the differentiation of two types of phonological dyslexia, but as no cases of isolated pseudoword difficulty were found, she also disputed the claims of dual-route theorists that such a specific disorder exists.

Friedman claims that the absence of any reported cases of pure phonological dyslexia (she, like many others, rejects Funnell's claims) combined with the inability of dual-route models to easily explain the actual symptom-complex of phonological dyslexia adds further weight to the superiority of single-route explanations of the process of reading aloud.

2.5.6.2 Phonological Dyslexia and Models of Reading Aloud

Friedman and Kohn (1990) state that the type of reading impairment which might be predicted following damage to the phonological lexicon would depend on which model of reading aloud was consulted. In a dual-route model, impaired access to the phonological lexicon would force the use of the GPC route and the reading errors that resulted from that would be caused by the application of a rule-based strategy, i.e. they would be regularisation errors of irregular words, whilst regular word and pseudoword reading would remain relatively intact. The dual-route model would therefore predict surface dyslexia as the result of a damaged phonological lexicon. In a single route model, if the phonological lexicon was damaged then both words and pseudowords would be affected. Irregular words would fare no worse than regular words of similar frequency, but pseudowords would be most affected.

Friedman & Kohn (1990) reported details of subject HR whose test results suggested that the area of his deficit lay in access to the phonological lexicon. He was able to read 14/25 regular words and 17/25 irregular words correctly, but only 7% of pseudowords. Of all the 622 errors that he made in total over a series of tests, only 1% could be classified as regularisations and all of these could also have been considered to be phonological in origin e.g. *noose→news*. Dual-route models predicted surface dyslexia after disturbance of the phonological lexicon, whereas the single-route model would predict phonological dyslexia. HR's performance was that of a phonological dyslexic, thus their results supported single-route models as the preferred type of model.

The SM89 model was able to simulate the AD performance of the Friedman et al. (1992) study (c.f. p.38), reading all but the non-analogous pseudowords well. This finding supported single-route theory, but also further indicated that normal skilled adult readers are able to use a GPC processing mechanism as a back-up procedure. This suggests that single-route models do not have this capacity, so they are not fully able to replicate what humans do in the way that humans do it.

Coltheart et al. (1987) admit the failure of the dual-route model to explain all the symptoms of deep dyslexia without relying on the existence of multiple lesions to the model. If the disorder arose from multiple lesions, then it would be expected that the manifestations of the symptoms would be variable. However Coltheart (1981) himself asserts that it is not the case. Therefore, the single-route model's more economic explanation would seem to be the more successful one. Connectionist systems behave more realistically than other models because they can be partially damaged and still function, and the more damage that occurs the greater the deficit (as reflected in the findings of Valdois et al. 1995). This pattern of degeneration is termed "graceful degradation" and is certainly one that appears to fit with the variable degrees of deficit reported in many of the case studies.

2.6 DUAL-ROUTE MODEL - PDP VERSIONS

Those who dispute that connectionist models actually perform reading in the way that human subjects do are not the only dissidents of the single-route approach. Coltheart, Curtis, Atkins and Haller (1993) contend the successful application of the single-route model, but do concede that the foundation of the model has two very beneficial features: the fact that it is computational and that it is able to learn. They developed a PDP version of the dual-route model which enabled them to maintain the two route architecture whilst incorporating these desirable connectionist features.

The dual-route cascade model (DRC) possesses an algorithm which learns the GPC rules embodied in the training set of words and is then able to apply these to novel letter strings. The cascade mechanism of the model demonstrates how the lexical route can contribute to pseudoword reading. The two routes mean that two different outputs occur at the phoneme level and the model deals with these by means of a lateral inhibition process so that any conflict can be resolved. To date, only the non-lexical route has been fully developed. This route has proved to be very successful in the pronunciation of pseudowords. However, words which do not possess one-to-one letter-to-sound mappings appear to have to be read by an extremely convoluted procedure. The authors do consider that the GPC route could be redundant, but they do not appear to consider that the lexical route could be the superfluous component. The complexity of the GPC route functioning and the fact that the learning algorithim is directed toward GP correspondence rather than being free to establish its own learning principles make it a less flexible approach to word reading than the single-route schemes.

Whitney et al. (1994) also devised a computational model of reading based on the dual-route theory. By degrading each of the routes in turn, they were able to reproduce patterns of pure surface and phonological dyslexia, i.e. damaging only one route so that the functioning of the other remained absolutely intact. Further investigations enabled them to reproduce the kind of error patterns which are generally displayed by people thought to have suffered just partial degradations in reading ability. They successfully reproduced surface dyslexia by reducing activation levels of word nodes so that low frequency words did not become active fast enough to over-ride input from the non-lexical route and, as a result, regularisation errors occurred. Similarly, by reducing the amount of activation reaching phoneme nodes and adding noise to that activity, they were able to simulate varying degrees of phonological dyslexia. The model has yet to have a semantic element incorporated into its structure. Whitney et al. maintain that the modelling of the reading process requires two distinct procedures and that the grapheme is the most appropriate size of unit on which to base the non-lexical component. Whilst appearing to explain those types of dyslexia which its structure has been developed to accommodate, there seems little reason to choose this model over the more parsimonious single route models which are able to explain the occurrence of the same disorders using only one route.

2.7 WHAT DO CONNECTIONIST MODELS MODEL?

At their conception, connectionist models were heralded as an antidote to the modular models which simply described a process as existing, but failed to explain the mechanics of how that process occurred. However, as they have increased in complexity, connectionist models have faced similar criticisms, for example it is felt that the existence of the distributed hidden units in many of the models (Figure 2.3) renders the connectionist models as opaque as their modular counterparts (Grainger and Jacobs, 1998).

In their damning report on the SM89 model, Besner et al. (1990), and later Buchanan and Besner (1993), declared that although the model may be able to perform word recognition tasks, that does not necessarily prove that it does so in the same manner as the skilled human reader. Indeed, despite the fact that the model is capable of learning to produce correct pronunciations by means of the orthography-phonology route, Patterson et al. (1996) allow that the human reader may not approach reading in precisely this way.

Although connectionist models can be seen as a statistical explanation of the reading process, Green (1998) queries what exactly can be learned about human cognition when it is modelled by a connectionist network in which so many features are optional. He argues that if neither the units nor connections represent any actual cognitive structure, such as neurons or synapses, then we can discover very little about any given cognitive process that is modelled in this way. He concludes that the only way in which connectionist theories of cognition might be considered credible is if they can be seen as literal models of brain operation. He demands that if these models are not representative of neural activity then cognitive scientists must be able to offer an explanation as to exactly what role they do fulfil.

In fact, it has been argued by some that the structure of the models does give them much greater neural plausibility than the classical models, i.e. they are arguably more representative of the physiology of the brain than the boxes and arrows of dual-route processing (McClelland, Rumelhart and Hinton, 1986; Harley, 1993). However, many others still maintain that the neural network has little in common with the real neural functioning of the human brain (Orbach, 1998; Greco, 1998; Opie, 1998). French and Cleeremans (1998) suggest that even if the nodes of connectionist models were designed to closely correspond to real neurons they would not actually be real neurons and so consequently the model would always be false at some level.

Lee, Van Heuveln, Morrison and Dietrich (1998) are at pains to distinguish between models and theories and their inherently different purposes. They state that a theory specifies the way in which a model matches the phenomena one is trying to explain. More particularly, a theory specifies an analogy between a model (a computer program in the case of a neural net) and the phenomena (the workings of the brain) to be explained. In essence, they argue that a model does not have to be isomorphic to the phenomena concerned in all respects, but only in the ones which it specifically proclaims to represent. They suggest that it is not only acceptable, but also usual, for a model to contain negative and neutral aspects as well as the intended positive similarities. Andrews (1995) too is keen to emphasize that models are simply metaphors used to explain a process, they are not intended as literal representations. According to this argument, it is of no consequence that connectionist models do not, for example, perform the lexical decision task as no attempt is made to make them to do so.

So, although Coltheart, Langdon and Haller (1996) may be correct when they state that a computational model is a tool not a theory, this is not necessarily the criticism which they intend it to be. Watters (1998) agrees that PDP networks should be regarded as valuable tools rather than models in the exploration of traditional theories. Connectionism is perhaps then best viewed as a progressive research programme which does not yet profess to have found all the answers (Thomas &

Stone, 1998). At the very least, it should be recognised that these models are able to make predictions which can then be tested and explored to encourage further observations.

However, it is necessary to be cautious in the continued development of this research. Whilst French and Cleeremans (1998) assert that as the ability to simulate cognitive function becomes more refined, the precise mechanisms of functioning will invariably follow, Coltheart (1995) warns that this is not the manner in which to proceed. He argues that knowledge of functional architecture must precede the construction of a model. Once a theory has been developed about how people perform a given cognitive task, then devising a connectionist model to simulate this enables researchers to determine if that theory is both sufficient and complete. On this basis he argues in favour of the DRC model, as its functional architecture is well defined, and against models which train themselves and thus effectively develop their own functional architecture, namely models such as the SM89 model.

Support for this criticism is provided by Norris and Brown (1985) who claim that the *ease with which the models can be modified to explain new phenomena highlights the great weakness of models expressed in the interactive parallel activation framework.* Yet it could be argued that such an ability is in fact part of the inherent strength of connectionist modelling. As McClelland (1989) emphasises, particular experiments test only a specific model, they are not tests of the connectionist framework in general. This notion is supported by Coslett (1991) who in his criticism of PDP models is keen to emphasize that he is only critical of the specific models to which he refers and he is willing to admit that models with slightly different construction may be able to accommodate the data more successfully. This is not true of the dual route model, as its architecture is too rigid and its connections too inflexible to be adapted without making major structural changes. In a purely theoretical sense this flexibility would appear to be a valuable feature, however in a clinical setting it is less satisfactory. For those who aim to use the models clinically, for either assessment or rehabilitation, relatively transparent and supposedly isomorphic models such as that of dual-route theory (Fig 2.1) are considerably easier to adopt. For this reason it is important to distinguish the processes in a computer model which are intended to be direct simulations of processes posited in the theory from those which are merely arbitrary technical assumptions adopted to start the process (Latimer,1991).

2.8 MODELS OF READING ALOUD: SIMILARITIES

Dual-route models have more recently been constructed with a connectionist architecture and single-route models have developed a subsidiary semantic route. It is widely agreed that as the models have continued to develop it has become more and more difficult to differentiate between them in any functionally useful sense (Patterson & Coltheart, 1987; Ellis & Young, 1988; Hildebrandt & Sokol, 1993). Both McClelland (1989) and McClelland, Rumelhart and Hinton (1986) posit that PDP models may in fact explain the microstructure of processes that occur within the macrostructure of the modular system. Slezak (1995) agrees, stating that the connectionist single route might be better viewed as an implementation level theory and that the two theories should be seen as providing complementary levels of analysis as opposed to being rivals. Conversely, Baaker (1995) suggests that as the exact functional architecture of the SM89 model has not yet been determined, it is possible that it is using some kind of dual-route mechanism, i.e. dual-route is the microstructure within the supposedly single-route architecture.

If the different models are now so similar as to be practically non-dissociable in many respects and are indeed mutually supportive in others, it questions what further investigations are necessary, or indeed what use they can be. Proving the superiority of one approach over another is difficult and of little value if, as McClelland (1998) posited, all current models are bound to be inaccurate anyway, although he did emphasize that they are not without worth in the search for the ultimate model of language processing.

The most apparent difference now lies in the nature of the storage of lexical items. The consequence of the structure of the two types of model is that dual-route models possess a lexical route and therefore a lexicon, whereas single route models do not. In the early stages of single route development, Seidenberg and McClelland (1989) insisted that this was one of single-route's most significant features. However, Besner et al. (1990) challenge the veracity of this claim. They suggest that, although there is no lexicon in the sense of there being a central word store in which each word is specifically represented, the distributed patterns which are stored are functionally equivalent to one as they provide a representation which links the visual recognition system, semantic and phonological systems. Perhaps then the notion of there being no lexicon has simply been over-emphasised in an attempt to dissociate the distributed models from the structure of lexical versus non-lexical routes which the existence of a lexicon might popularly be taken to imply. As yet, little attention has been given to the structure of the lexical route of the DRC model, so it is not clear how dissimilar it might be from that of the more traditional connectionist models.

The differences between the models are becoming increasingly difficult to distinguish and investigators must consider the issues that arise within both theoretical frameworks (Treiman, 1990). As Slezak (1995) states, the issue which must now be focused on is not simply the comparison of the models in terms of their empirical performance, but rather the identification of the criteria which will make that comparison a valid and useful one. Any such comparison must surely relate to what Baaker (1995) recognises as the most important measurement of the models' relative successes, how well they are able to account for human data.

Monsell et al. (1992) state that it is an incontrovertible fact that to be able to read aloud all real words it is necessary to use correspondences at least at two levels (a lexical/whole word level and a sublexical level of mappings between constituent spelling patterns and their pronunciations) and that the theories differ only in the way in which they implement these patterns. Plaut (1995) identifies the distinction between regularity and consistency in the processing of letter strings as being intimately related to the tension between the theories. It is proposed that this issue should therefore form the focus of an investigation into how competently the two theories are able to account for clinical data.

2.9 WORD CLASSIFICATION

It is the issue of word classification that forms the focus of this study. The aim is not only to possibly determine which theory provides a better account of reading aloud difficulties, but more specifically to investigate which method of word classification can provide speech and language therapists with the most useful information for assessing and remediating such difficulties. Issues of regularity and other methods of word classification have been briefly referred to so far. The following section will discuss in detail the various approaches and their relationship to the models of reading aloud.

2.9.1 REGULARITY

As has already been stated, English spelling is only quasi-regular in structure and therefore not all English words can be pronounced according to a rule-based strategy. When word classification was initially attempted, it was done so on a letter-to-sound by letter-to-sound basis which allowed only for the literal translation of single letter units into sound units (phonemes). Regularity is largely limited by two factors, the fact that most characters can correspond to several different sounds and that many characters can both stand alone and be combined in various ways for pronunciation as a single phoneme. In fact there may be as many as four different phoneme correspondents for consonant characters and up to nine for vowels (Berndt, D'Autrechy & Reggia, 1994). Consequently, this method fails to satisfy the pronunciation demands of too large a percentage of words to be of any real value (Wijk, 1966; Venezky, 1970) and so a larger unit, the grapheme, came to be considered as the most relevant unit of spelling. A grapheme can be up to four letters in length, the only stipulation being that the whole letter group must correspond to only one phoneme.

Venezky (1970) developed a rule-based system which used the grapheme as the functional unit of spelling-to-sound (grapheme-to-phoneme). This system recognised three types of words:

- Major correspondences
- Minor correspondences
- Exceptional correspondences

As has already been described in some detail, Coltheart (1978) considered the implications of exception word reading for skilled adult readers and consequently devised the dual-route model. The supporters of this model accepted that exception words were a heterogeneous group which embodied many different forms of spelling-to-sound irregularity e.g. final e, vowel digraphs (Coltheart et al., 1979), but also assumed that such words were dealt with in a homogeneous fashion. It is perhaps this fixation on irregular words as a collective group, around which theories of pronunciation could be developed, that has been largely responsible for the myth that there exists a straightforward dichotomy of regularity.

Regularity is considerably more complex than the simple two-way division that is encapsulated in the dual-route principle. Shallice, Warrington and McCarthy (1983) re-instituted Venezky's three-way division by identifying words in the following way:

- Regular - all GPCs most frequent in English for the relevant graphemes

- Mildly Irregular - each contain one GPC which is unusual but not exceptional
- Highly Irregular - containing multiple irregularities or an exceptional correspondence

Whilst their experimental evidence supported this division as a better fit for the data than the more generally favoured dichotomy, attempts to devise a clinical test using a similar three tier continuum of regularity did not succeed (Rothi, Coslett & Heilman, 1984). This failure was, in part, because this approach to delineating regularity increases the subjectivity of the classification, which in turn makes devising a suitable test battery for experimental manipulation very difficult.

Some words may be regular or irregular depending on the criteria which are selected (Friedman, 1988; Paap & Noel, 1991). Considering word units in statistical rather than categorical terms might be a means of reducing the subjectivity of classification (Venezky, 1970; Seidenberg and McClelland, 1989). On this basis Berndt, Reggia and Mitchum (1987) calculated the grapheme-to-phoneme probabilities of each recognised grapheme unit, to obtain statistical scores for the likelihood of a given grapheme being pronounced in a particular way. Although seemingly an objective means of classification, in practice this method also presents a number of problems. Most notably, some graphemes score 1 when they are the only example of a particular orthographic combination e.g. *-cht* in *yacht*. This implies that such words are totally regular and so, even with the authors' warning that frequency of occurrence of a particular phoneme does not equal frequency of occurrence in the language, such scores are rather misleading. An additional issue is that the system was based on North American English, so it is directly suitable only for speakers of that dialect as it does not allow for the different characteristics of other accents e.g. the rhotic, post-vocalic *r* in Scottish-English.

Perhaps more importantly, as Glushko (1979) suggests, there is not necessarily any relationship between the linguistic descriptions of words in terms of rules and a reader's actual knowledge of the structure of his language. That is to say that rule systems may have a linguistic basis, but they do not necessarily have a psychological one. Treiman (1992) concurs with this view, suggesting that just because English is an alphabetic language it does not necessarily follow that it must be described, used and learned only at the level of graphemes and phonemes.

2.9.2 ORTHOGRAPHIC NEIGHBOURS

In addition to actual knowledge of a specific word and possession of a rule-based system, Coltheart (1979) proposed that readers might invoke knowledge of a word's orthographic neighbours to provide assistance in its pronunciation. For example, he considered the orthographic neighbours of *mill* to be *milk, mull* and *pill.* However, the numerous conflicts that would occur in such a method of assimilating pronunciation suggest that even for the most regular words pronunciation speed would be extremely slow.

Instead of such complex processing, Parkin and Underwood (1983) suggest that the Venezky rules may represent only part of the tools that a skilled adult reader is able to employ. They argued that rules should extend beyond the level of GPC to incorporate larger orthographic units. As an example they showed that whilst *head* is irregular by GPC, it becomes regular if –ead (the word body) is taken as the basic unit of analysis and would therefore be more likely to be read correctly.

Consideration of the word body as a basic unit of pronunciation moves away from regularity and the dual-route model to models of reading aloud such as the multiple levels and the analogy model. Numerous researchers have considered the consistency of spelling-to-sound relationships between words (Glushko, 1979; Rosson, 1983; Kay and Lesser, 1985). Plaut (1995) provided the most concise summary of the differences between regularity and consistency, he stated that *a word is regular if its pronunciation can be generated by rule and consistent if its pronunciation agrees with those of similarly spelled words.*

Treiman (1994) emphasizes the importance of lexical statistics in relation to models in which processing a given word is dependent on all the other words that are known to the reader. She states that if these models are to be proved correct, it is necessary to understand the statistical nature of the input that is available to the reader. The difficulty lies, in knowing what aspects of the input to count (Venezky, 1970). Plaut et al. (1995) indicate that there is a pragmatic reason for using word bodies to test their theories, i.e. word bodies are easy stimuli to identify and control. Whilst this fact may make the creation of test batteries relatively easy, word bodies could not truly be considered as valuable test stimuli if they were found to have no psychological reality.

Combinations of friend-and-enemy effects arise naturally from the way in which connectionist models learn so the relevance of word bodies really may be an artefact of the structure of the model rather than a psychological reality (Brown, 1997). However, on the evidence obtained from normal subjects concerning consistency effects, Jared (1997) concluded that her results suggested that models of word reading have to accommodate the fact that pronunciation of any given word can be influenced by knowledge of the pronunciation of other words.

Treiman (1994) suggests that the SM89 model identifies the word final VC units as relevant not because they are explicitly represented in the model but because of the statistical properties of the language. Treiman and Zukowski (1988) found final VC units to be the most significant. There are two primary units in spoken syllables, the onset and the rime. It could be argued that these units are merely phonological and are not mirrored in printed words since, as Coslett, Rothi and Heilman (1985) point out, reading and speech are dissociable and might therefore depend on different units. As consistency effects were not found in the lexical decision task, Jared, McCrae and Seidenberg (1990) suggest that they are genuinely phonological and not orthographic effects. If this were the case then word body would have limited use as a tool for testing orthographic processing ability.

However, a study by Treiman (1994) indicated that there is some correspondence between units of print and speech and that it would appear that this lies at the level of onset and rime. Bowey (1993) suggests that onsets and rimes may function as units of working memory as well as units of print and provides further support for the use of rimes in orthographic as opposed to just phonological classification. She argued that if orthographic rimes function as units of the initial word recognition process then stronger priming effects should be observed with orthographic rime primes than with phonological rime primes. However, if orthographic rime priming effects reflect a form of phonological priming, then equal effects should be observed for both types of prime relative to the control in which target words receive no priming at all. Bowey found no evidence for phonological rime primes, thus confirming that orthographic rimes serve as effective functional units of adult word recognition and as such have important theoretical implications.

Treiman (1994) also suggests that orthographic rimes may not be isomorphic to phonological rimes, that they occur not because of their relation to linguistic units, but because of the properties of the orthography itself, i.e. certain letters are processed as a unit because they often appear together in words. This further establishes the statistical reality of such units.

Investigations of the development of reading suggest that an analogy strategy is employed (Bruck & Treiman, 1992) and that children make analogies more easily when words share rimes (VC) units, than when they share initial consonant + vowel (CV) units. However, it was found that for learning reading, rime based analogy had a limited use as this method did not yield the best long-term results. This may be because as the rime training was easy, children were able to process the words with less effort than in the non-analogy conditions and therefore retention was poorer, or it may have been that they focused more on the process of pronouncing the words than on the words themselves. The analogy strategy applied by the children in this experiment was a conscious one, in which they recalled a similar word and then modified its pronunciation. However, Damper and Eastmond (1997) proposed that analogy could be implicit as well as explicit and therefore it may be that once adult readers have established vocabularies they are able to apply analogy implicitly in a manner not available to the children.

Following the findings of Glushko (1979; 1981), Henderson (1982) proposed that there might be two types of word which would be most unsupported in terms of neighbourhood. These he termed *heretics* and *hermits*. Heretics, are defined as words which share an orthographic body, but not a pronunciation with other words, e.g. *pint* which has the same body as *mint, hint, tint* but which has a conflicting pronunciation. They would suffer in terms of pronunciation because not only do they not have the support of other words, they also have a pronunciation conflict. Hermits on the other hand, are words which share their body with no other words and thus have no neighbours to support their pronunciation, e.g. *soap* is the only monosyllabic word in the English language with the body ending *–oap.*

Patterson and Morton (1985) provided a much more extensive breakdown of neighbourhood types including "ambiguous conformist words" e.g. *cove* which has a regular pronunciation but has neighbours with a variety of irregular pronunciations e.g. *love* and *move* and "gang words without a hero" e.g. *cold* where all the words have an irregular pronunciation. An approach such as this makes the categorisation of words an extremely complex process and other researchers have identified a reduced number of body neighbourhood categories which are able to account for the most pertinent divisions of spelling-to-sound consistency.

2.9.2.1 Frequency and Neighbourhoods

Brown (1987) proposed that frequency rather than regularity of spelling to sound patterns might be a better differential of word types. He claimed that spelling to sound regularity and frequency of a given spelling pattern are confounded in the usual comparisons of word types. Three types of words were identified which, when compared would enable the delineation of the two factors.

- Common/consistent words have spelling-to-sound correspondences that are both frequently encountered and regular e.g. *hill, mill, pill.*
- Exception words which have both unique and irregular correspondences e.g. *pint* which is the only word with terminal *–int* which does not rhyme with *mint* (equivalent to Henderson's heretics)
- Unique words which have unique spelling-to-sound correspondences but, like common/consistent words, they are also regular e.g. *soap*, there are no *–oap* exceptions to this spelling-to-sound relationship (equivalent to Henderson's hermits)

Brown compared performance on words that varied on frequency but not regularity, i.e. no friends, no enemies (unique) versus many friends, no enemies (common/consistent) and then performance on words that had the same frequency but not the same regularity i.e. no friends, no enemies (unique) versus no friends, many enemies (exception). The findings showed a significant difference in performance in the former, but not the latter instance. This supported an effect of correspondence frequency, a friends effect, but not a regularity (enemies) effect. Thus Brown argued that consistency of pronunciation was not separable from frequency of occurrence. He claimed that unique and exception words should belong to the same category, as for all the words in both categories there was only one body with that particular pronunciation and that the difference between the two categories, the presence/absence of enemies, was irrelevant.

Consequently, Brown's (1987) facilitation model predicts that consistent and inconsistent words with the same number of friends should be read with equal speed because they would receive the same support from friends and the enemies to the inconsistent word pronunciation would not wield any influence. However, Seidenberg and McClelland (1989) found that the SM89 model simulation read inconsistent words significantly more slowly than consistent words, suggesting that some interference effect did occur from enemies within their model. An experiment with human participants confirmed this prediction. Jared, McCrae and Seidenberg (1990) found that the size of the consistency effect depends on the relative frequency of friends and enemies rather than on their relative numbers as was originally proposed by Brown (1987). Brown's suggestions are also refuted by the findings of Armstrong (1993) who identified unique words as the type of word on which a group of people with dysphasia produced the greatest number of errors, thus supporting the division of unique and exception words.

Brown and Watson (1994) also investigated the delineation of rime units in terms of orthography and phonology at the same time as further investigating neighbourhood effects. They suggested that the friends effect found by Brown (1987) might have been inflated by the influence of neighbourhood size. They observed that words with many friends will obviously have larger orthographic neighbourhoods and that phonological factors could also affect the speed at which the words are read.

Just as Brown (1987) illustrated that factors of frequency and regularity were often confounded, so Brown and Watson (1994) demonstrated that a similar situation was still occurring in his experiments between orthographic neighbourhood size and number of friends. In the friends effects comparisons, common/consistent words have many friends and orthographic neighbours whereas unique words have neither. Similarly, in the enemies effects investigations, exception words have many enemies and orthographic neighbours whereas unique words again have neither.

As an alternative to Brown's (1987) facilitation model, Brown and Watson (1994) propose a Cancellation Hypothesis, whereby an orthographic neighbourhood effect which supports exception words cancels out an underlying enemies effect which supports unique word reading. They suggest that Brown failed to find an enemies effect due to the low summed frequency of enemies in the stimuli. On equating the summed frequency of enemies, it was discovered that there was in fact an influence of a word's inconsistency (the absence or presence of enemies). It is also noteworthy that words with large neighbourhoods usually possess higher frequency neighbours, i.e. neighbourhood size and neighbourhood frequency typically co-vary (Sears, Hino and Lupker, 1995). Brown and Watson concluded that both friends and enemies combine to determine word naming latency.

As numerous experiments have shown, manipulating body neighbourhoods has an observable and systematic effect on performance, consequently Jared, McCrae and Seidenberg (1990) conclude that word body has perhaps the largest influence on word pronunciation and they identify the following categories as the most pertinent for use in investigations of reading aloud:

- **Consistent** words - words where all the body neighbours share a pronunciation e.g. *mill* with neighbours *hill, till, pill.*
- **Inconsistent** words - words which have many friends and one enemy e.g. *mint, hint, tint* with the enemy *pint.*
- **Exception** words - words with only enemy body neighbours e.g. *pint* with enemies *mint, hint, tint.*
- **Unique** words - words with neither friends nor enemies e.g. *soap, yacht.*

However, they also emphasize the importance of recognising that word body is not necessarily the only relevant unit, and state that the degree of influence exerted by body neighbours will be dependent on the inhibitory strength of alternative pronunciations. They suggest that this may be particularly true in the case of unique words which have no body neighbours to influence their pronunciation in either an excitatory or inhibitory sense and also that a weak neighbourhood of friends and a strong neighbourhood of enemies will produce the strongest effect.

Jared (1997) found that high frequency inconsistent words yielded longer pronunciation latencies than matched consistent words. The effects were strongest in the presence of low frequency friends and high frequency enemies. These findings are not predicted by any of the current theories of reading aloud. She suggests that they might be most damaging to dual-route theories as their view is that high frequency words are retrieved from the lexicon without input from knowledge of other words. Her findings clearly imply that there must after all be competition between the pronunciation of a high frequency word and its orthographic neighbours. She proposes that connectionist models would only be threatened if they were unable to adapt their structure to account for the results. However, her findings have implications not only for both the theoretical paradigms, but also for the regularity versus consistency debate. She initially used a word body definition of consistency to determine the stimuli for her experiments, consequently the inconsistent word lists contained some words which are irregular according to GPC and some which are regular. A further experiment examined whether the degree of word body consistency or the individual letter-sound correspondences were accountable for the results. The finding that there was still a consistency effect for entirely regular words shows that GPC rules are not sufficient to describe the correspondences which skilled readers invoke. However, the results also indicated that word body consistency alone does not provide an adequate explanation either. She suggests therefore that either GPC rules need to be incorporated into a lexical competition model that also allows for consistency effects, or that consistency needs to be described at both single letter and word body levels.

2.9.3 CLASSIFICATIONS MEET

There is in fact a quite considerable body of evidence which suggests that both GPC and word bodies may have a role to play. Schwartz et al. (1987) found evidence that

GPC rules may play an increasingly important role in performance over time. Perhaps then when word body units are intact, GPC processing is somewhat irrelevant. This supports the findings of Shallice and McCarthy (1985) that higher levels of unit degrade more quickly. Their assertion that an increased number in the possible processing units produces greater loads in acquisition, discrimination and transmission may provide an explanation for this degradation – the processing demand may be too great for those with neurological damage and thus they rely on the smallest possible units.

However, Friedman, Ferguson, Robinson and Sunderland (1992) claim that their evidence from people with AD shows that conscious GPC application is only available to readers who are cognitively intact. They suggest a hierarchy of processing, that we read first by analogy and then, failing that, by conscious GPC. So, although they support the notion of graceful degradation of the larger units, they also seem to imply that cognitively impaired patients have no substantial GPC mechanism to rely on. Further evidence of graceful degradation may come from those letter-by-letter readers who, due to brain damage, are unable to use any form of parallel processing of more than one letter and so name each individual letter in turn (Coltheart, 1984).

Additionally, Ehri and Robbins (1992) suggested that children may need some decoding skill before they can read words by analogy. This build-up to the use of analogy strategy involving word rimes might be considered to mirror the graceful degradation of processing ability found in adults with acquired dyslexia. It has been suggested that they lose the ability to pronounce words using word bodies prior to losing their ability to apply of GPC rules. Both Treiman et al. (1995) and Jared (1997) concede that word body is probably not the only unit relevant to pronunciation, but that it is particularly salient.

A possible explanation for the apparent psychological reality of word body units may be found in the theory that the deterioration of semantic knowledge affects lexical representations (Patterson and Hodges, 1992). One of the effects of this damage would be that the phonological elements of words would be disconnected and therefore become more prominent in their own right. This would presumably affect the most obvious phonological divisions such as onset and rime making them most vulnerable to experimental manipulation. This does of course mean that such units may not be as relevant to normal reading as they are to disordered reading.

A further cause for concern is highlighted by Berndt, D'Autrechy and Reggia (1994) who state that although there is much evidence to support the notion that print-to-sound mapping in monosyllables may involve segments that are larger than graphemes and phonemes, it is not clear that these larger units are useful in processing multisyllabic words. Indeed, such units might prove to be a hindrance as they will increase the conflicts that seem likely to occur in polysyllabic word pronunciation. However, whilst acknowledging that most studies concentrate on monosyllabic words, Treiman, Fowler, Gross, Berch and Weatherston (1995) provide evidence that such studies are also relevant to the processing of multi-syllabic units. They contended that the structure of a polysyllabic word and the subsyllabic elements of onset and rime need not necessarily conflict. Results of their experiments showed that whilst the initial onset of a polysyllabic word is afforded a particular status, the remaining syllables of the word are divided into onset and rime units. These findings appear not only to support the word body as a functional unit, but also add credence to the use of monosyllables as stimuli in tests of reading aloud as results from such studies might be generalised to inform investigation of the processing of larger lexical items.

2.9.4 CONCLUSION

Seymour (1992) identified two components which he considers to be necessary for successful cognitve assessment: a comprehensive model of the cognitive system and the use of tasks and stimuli which are suitable for testing that model. In this chapter, two different approaches to the modelling of reading aloud have been presented. Each approach uses a particular means of categorising words in order to test its validity and diagnose difficulties in clinical patients. As the above discussion has shown, no current method of classifying words is without some flaws. Regularity is highly subjective and issues of neighbourhood size, friends, enemies and cumulative frequencies frequently confound the use of body neighbours as investigative stimuli.

The choice of stimuli in an investigation is intrinsically linked to the researcher's beliefs about the underlying nature of word representation and therefore to the particular theoretical model which they support. The performance of people with dysphasia on certain word types has been considered valuable in the garnering of support for, or opposition to, the various theoretical stances. The current study was concerned with what information performance on different word types can provide about the nature of single word reading in dysphasia.

By investigating the performance of a group of people with dysphasia on a series of tasks which used stimuli categorised by regularity and also by body neighbourhood, it was proposed that:

a) It would be possible to determine which method of classification provides the more comprehensive view and explanation of the performance of people with dysphasia.
b) Such information would also be seen as providing support for one of the two major branches of current theories of reading aloud.
c) An investigation of the nature, as well as the number, of errors made would provide an additional source of clinically useful information.

The choice of stimuli and methodology of the chosen tasks are described in the following chapters.

CHAPTER THREE: PILOT STUDY

3.1 INTRODUCTION

In the first sections of this chapter (3.2 & 3.3) the methods by which the test stimuli were selected and piloted are described. The following section (3.4) discusses the proposed inclusion and exclusion criteria for the identification of potential participants for the main investigation. The choice of both stimuli and criteria are fully evaluated in a discussion of two studies which were carried out and analysed prior to the commencement of the main investigation. The first study, (described in 3.3), was a straightforward pilot study, involving unimpaired participants, to determine the appropriateness of the chosen stimuli. The second (discussed in 3.5) was a more complex experimental investigation. As well as seeking to establish the sufficiency of the suggested participant-selection criteria, it also sought to investigate and compare the response time performance to the selected stimuli of a group of people with dysphasia with that of a group of matched unimpaired controls. The findings from this study are then summarised and discussed in terms of their relevance to the methodology of the main investigation.

3.2 STIMULI

The selection of the real word stimuli and creation of the pseudoword stimuli is discussed in this section. A full list of the stimuli and their relevant features is provided in Appendix One.

3.2.1 REAL WORD STIMULI

In Chapter Two, it was discussed that the two main branches of reading aloud theory invoke two different approaches to word classification. Single-route theory generally considers words in terms of their body neighbourhood type, whilst dual-route theory supports the division of words into a regular-irregular dichotomy. One of the main aims of this project was to determine which, if indeed either, type of classification provides the more comprehensive picture of the general reading aloud abilities of people with aphasia. In order to investigate this, it was necessary that each item in the test battery be classified according to both schemes. Both theories recognise the influence of word frequency with regard to the success of reading aloud, so items were also classed according to their frequency.

Ideally, from the point of view of statistical analysis, there would have been an equal number of stimuli in each sub-division of each of the three paradigms, body neighbourhood, regularity and frequency. However this was not viable due to the particular nature of the stimuli. Obtaining roughly equal groupings in terms of body neighbourhoods rendered it impossible to do the same with the regular/irregular listings. There is therefore a considerable imbalance in the spread of stimuli across some sub-divisions. The statistical implications of this are discussed in Chapter Five.

3.2.1.1 Body Neighbourhoods

As categorisation by body neighbourhood requires the division of items into four word groupings, rather than the two of the regular/irregular approach, stimuli were classed according to this paradigm first. They were categorised by the body neighbourhood criteria used in the experiments of Jared, McCrae and Seidenberg (1990). Four categories of words were considered:

- **Consistent** words - words where all the body neighbours share a pronunciation e.g. *mill* with neighbours, *hill, till, pill.*
- **Inconsistent** words - words which have many friends and one enemy e.g. *mint, hint, tint* with the enemy *pint.*
- **Exception** words - words with only enemy body neighbours e.g. *pint* with enemies *mint, hint, tint.*
- **Unique** words - words with neither friends nor enemies e.g. *soap, yacht.*

To ensure that the categorisation was exact, once a word had been selected, all the possible monosyllabic letter strings which could be created by changing the onset to another consonant or consonant cluster were systematically investigated using the Chambers 20th Century Dictionary (1983). Words deemed to meet the criteria for inclusion into a particular group were then checked again against the neighbours generated by the CELEX Lexical Database (Baayen, Piepenbrock & van Rijn, 1993) when frequency scores for all the items under consideration and their neighbours were being retrieved.

Any words which were found to have proper names as body neighbours were automatically excluded from the study as their properties may affect the strength with which they, and possibly also their neighbours, are established in the lexicon, for example, *fleece* was excluded because of its body neighbour *Greece*. Indeed, the only body neighbours which were not considered relevant when determining the suitability of an item for inclusion in a particular class were Olde English words which, whilst still often included in modern dictionaries, are not listed in lexical databases nor are they in common usage and would be unlikely to influence the results in any way.

3.2.1.2 Regularity

The selected words were then classified as regular or irregular based on the criteria established by Venezky (1970). The GPC rules described by Venezky were applied to each word in turn to determine the status of its regularity. In addition, scores were calculated for each word using the system devised by Berndt, Reggia and Mitchum (1987). This determines the probability of a word being pronounced correctly based on the most common pronunciations of its component graphemes. It was anticipated that this system would provide a more objective means of determining the regularity of a word and that this might be a better predictor of successful reading aloud performance.

3.2.1.3 Frequency

Frequency scores were obtained for all the selected words and for all their body neighbours using the CELEX Lexical Database. This particular database was chosen rather than the more commonly used Kucera and Francis (1967) because it has been derived more recently and uses a larger corpus of words. Words were categorised as high or low frequency accordingly and cumulative frequencies for neighbourhood friends and enemies were then calculated where applicable.

3.2.2 PSEUDOWORD STIMULI

Pseudoword letter strings were included in the stimuli list as they are considered of both theoretical and clinical importance in the identification and differentiation of surface and phonological dyslexia. They are also argued to be of value as test stimuli as they may provide further insight into the manner in which real words are processed. Non-word letter strings can be constructed to have all the orthographic and phonological properties of real words without the additional complexity of semantic input. Consequently, for this study a series of orthographically legal letter strings which have no meaning in English were devised. In order to allow as close a comparison as possible between word and non-word letter string pronunciation, the pseudowords in this study were created by altering the onsets of all the real word stimuli. These stimuli corresponded to three body neighbourhood types:

- Consistent-based pseudowords e.g. *prill* from *hill, mill, pill*
- Inconsistent/Exception-based pseudowords e.g. *jint* from *hint/pint*
- Unique-based pseudowords e.g. *goap* from *soap*

A fourth group of non-words was also adopted, these were composed of phonotactically illegal combinations of letters, e.g. *coew*, and were termed "strange" pseudowords. Such stimuli elicit psycholinguistically interesting behaviour in normal subjects and so they were included in this study in order to determine whether participants responded similarly to all types of non-word letter string, or if their behaviour differed depending on the "word-like" quality of the stimuli.

A further set of phonotactically legel non-word letter strings were also created which did not correspond orthographically to real words, but which could do so phonologically, for example *poap* which might be pronounced as the real word *pope*. These too were established by altering the onsets of the real word stimuli, e.g. *poap* was derived from *soap*, and are termed pseudohomophones.

3.3 PILOT STUDY

In order to determine that the categorisation of words was correct according to the native population of the study, particularly in relation to body neighbours which might receive different-to-standard pronunciations depending on regional accent and might therefore differ in their categorisation, the test battery of both real and pseudowords was piloted on a group of skilled adult readers. This also provided an opportunity to investigate the level of consensus of pronunciation (Masterson, 1984) for the non-word letter strings.

The participants were a group of 20 first year Speech and Language Therapy Students in the Department of Speech and Language Sciences at Queen Margaret College, Edinburgh. They were asked to read first the words and then the pseudowords as clearly and precisely as they could. Students were given no insight into the background of the project prior to taking part in the study, so they were not primed in any way as regards pronunciation by analogy or any other strategies.

Following a transcription of their outputs, it was necessary to change only one of the actual categorisations and to remove two unique words, *ankh* and *neume*, from the stimuli set as they proved particularly difficult for the students to read aloud correctly.

3.4 PARTICIPANT SELECTION

Many investigations of reading aloud disorders focus on a single case study of a person considered to have a very specific form of an acquired dyslexia, yet these isolated cases are seen in clinical settings, but rarely. It was hoped that the results of this investigation would be applicable to the more general clinical population, so it was decided that the performance of a group of people with mild-moderate dysphasia should be investigated in both the pilot and main studies. In order to ensure that the performance of participants in the study truly reflected their abilities with regard to the test stimuli and tasks in question, and was not influenced by any other factors, e.g. limited vision or motor control, a number of criteria were adopted for the inclusion of possible participants. The following criteria were initially proposed:

- To ensure neurological stability, participants should be at least one year post-onset of their CVA
- Many reading impairments in CVA patients are a result of visual perceptual difficulties rather than a cognitive impairment per se, so participants should have normal, or corrected to normal vision
- So that differences in accent could not affect the results, participants should have English as their first language and be native Scottish speakers
- If dysarthria were present it would not be possible to tell whether errors, particularly phonemic errors, were actually evidence of an impairment of

reading, or simply a result of the motor speech disorder, so participants should have no significant dysarthria

3.5 RESPONSE TIME STUDY

3.5.1 INTRODUCTION

The measurement of participants' response times to stimuli is a commonly used technique for investigating the underlying representations or internal processing of specific types of words in normal participants. This is due, at least in part, to the fact that the number of errors made by such participants are usually minimal and are therefore able to offer little information on normal functioning. Consequently, theories of normal processing are often informed by response time, or pronunciation latency, studies. If it is indeed correct to assume that differing response times reflect the strength of underlying representations then it might be anticipated that, although people with dysphasia will be considerably slower overall than unimpaired participants, both groups will display similar patterns of pronunciation latency. This particular study aimed to compare the response time performance of a group of people with dysphasia with that of an unimpaired control group in order to determine the similarities in their performance.

Investigations of disordered processing, such as that manifested in people suffering from neurological damage or degeneration, generally focus on the inflated number of errors which are made as a result of the affliction. It is anticipated that response time and error score data can be equated, such that longer latencies on certain items in normal participants might be expected to be mirrored by higher error rates on those same items in participants with acquired dyslexia. Should this not prove to be the case, then it may indicate that response times and error scores do not provide information about the same skills or representations. The response time data gathered in this study are compared, at a later stage, with the number of errors that people with dysphasia made in the reading aloud study. This comparison provides a valuable test of the validity of equating response time data with that of error scores.

3.5.2 AIMS

The experimental aims of the study were:

1. To compare the response time performance of people with and without dysphasia
2. To investigate if word frequency, regularity and/or body neighbourhood affect those response times
3. To determine if response time patterns are maintained across word and pseudoword stimuli of similar neighbourhood types.

This study also had a number of aims which related directly to the preparation of the methodology for the main investigation. These were:

a) To investigate the practical issues which might affect the gathering of response time data in the main study
b) To ensure that participants with dysphasia could cope with the volume and nature of the stimuli
c) To monitor the suitability of the proposed inclusion criteria for identifying participants for the main study

3.5.3 HYPOTHESES

- **The Similarity of Performance Hypothesis**

  The performance of people with dysphasia will be slower overall than that of the control participants, but the response time patterns per se will not differ across the two groups of participants (c.f. 3.5.1).

- **The Word Type Hypothesis**

  Previous findings indicate that response times can be affected by the regularity or body neighbourhood to which a particular word belongs (2.3.7). Therefore, it is hypothesised that *there will be distinct response time patterns across types of body neighbourhood, and across the regular-irregular dichotomy.*

- **The Pseudword Hypothesis**

  Body type has been found to affect performance on both words and pseudowords (c.f. 2.4 & 2.4.1) and thus it is proposed that *the response time patterns for pseudowords will match those of their real word body neighbours*, for example if unique words have the longest latency scores then the unique-based pseudowords will have longer latency scores than the other types of pseudowords.

3.5.4 PARTICIPANTS

In accordance with the proposed inclusion criteria, five people with dysphasia were recruited through the therapist at the speech and language therapy clinic at Queen Margaret College, Edinburgh. Participants to act as controls were recruited locally through personal contacts. They were matched for sex, occupation-type and age. The importance of age-matching is emphasised by the findings of Allen, Madden, Weber and Groth (1993) who demonstrated that older people perform less well than younger people on tasks which involve phonological encoding. Therefore the people with dysphasia and their counterparts were matched for age to within a three-year period.

3.5.5 STIMULI

All of the 232 real words identified as suitable stimuli and classed according to frequency, regularity and neighbourhood together with their non-word counterparts were used in this study. Burt and Humphreys (1993) found evidence of inter-list priming occurring when words with the same body but different pronunciations were presented in the same list, so the real word stimuli were divided into two groups to prevent this. Exception words and their inconsistent neighbours were therefore separated, e.g. *pint* and *mint* were in different data sets. As intra-list priming effects have also been found when spelling patterns are repeated (Seidenberg, Waters, Barnes & Tannenhaus, 1984), the two lists were presented at weekly intervals. The non-word stimuli were presented on a third separate occasion for the same reason.

3.5.6 EXPERIMENTAL DESIGN

A Macintosh-based program, Psyscope, was used to present the experimental stimuli. Recordings were made in a sound-proof studio booth in order to ensure that the recording was of sufficiently high quality for detailed analysis and also to ensure that participants were not distracted by external factors which might then result in some of the response time data having to be rejected. The experiments were recorded on a DAT recorder, the levels of which were continuously monitored by an experimental technician to ensure that the recording quality was maintained. In order to measure response times accurately it was vital that there be an absolute and standard point from which to make the measurement. The program was developed such that a beep sounded simultaneously with the appearance of a word on the screen, this ensured that when the recording was analysed, it would be possible to record with certainty the distance from the onset of the beep to the onset of the participant's voice, i.e. the response time.

The stimuli were presented to each participant in a random order generated by the computer so that the results could not be said to be an artefact of the order of presentation, i.e. response times for particular stimuli could not be said to have been artificially inflated simply because those stimuli had always been presented at the end of the task when the participants were becoming tired and were less attentive than on other earlier items. The computer program was designed so that a participant with dysphasia and their matched control were presented with items in the same order, again to ensure that the comparisons were as valid as possible.

It was considered important that the participants were as comfortable as possible with the experimental situation to ensure that they performed at their optimum level. Participants were given control of the mouse and instructed that each time they pressed it they would hear a beep and a word would simultaneously appear on the screen. They were requested to read the word as quickly and as accurately as possible. The first five items at the start of each block were filler items to familiarise the participants with the whole process. None of these items were included in the final analysis.

3.5.7 ANALYSIS

The data which had been recorded onto DAT tape was first transcribed phonetically and then fed through a PC-based *Soundblaster* program which, by analysing sound wave patterns, allows the time lapse from the beep to the onset of the participant's response to be measured in milliseconds. Thus a response time was obtained for each response to all the stimuli items. Response times were then grouped according to the various stimuli classification categories (regularity, frequency etc.) in order to carry out the required analyses.

The number of participants involved in the study was small, so a parametric by-subject one-way analysis of variance (ANOVA) would not be viable. Therefore, to compare the performance of the two groups of participants, the non-parametric Mann-Whitney U test was employed to allow the use of mean response times to each of the word types. To measure the performance of the two participant groups individually, by-item ANOVAs were used.

3.5.8 RESULTS

A number of issues arose which affected the analysis of the data, these are discussed in 3.5.8.1. The results of the statistical analyses are then presented in the ensuing sections.

3.5.8.1 Difficulties with the Initial Processing of the Data

The data of the control participants was relatively straightforward to analyse acoustically in order to obtain the response time scores. Apart from occasional errors, all the participants responded clearly and correctly to the majority of the stimuli. Only the response times for correct responses were included in the analyses. In the case of the control participants, this allowed the inclusion of 98% of the real word data and 95% of the non-word data.

However, the data of the people with dysphasia were not nearly so exact. Not only did they make considerably more errors on both the real and non-word stimuli than their control group peers, but they also frequently refused to attempt many of the non-word stimuli. Whilst this refusal is in itself of interest when considering the ability of people with dysphasia to read non-word stimuli, for this particular investigation it meant that a considerable amount of the data from this participant group had to be recorded as missing which may then affect the validity of the comparisons between the two participant groups. In addition, the people with dysphasia made numerous false starts and attempts at self-correction all of which invalidated the data, so these responses also had to be counted as missing data wherever they occurred. This meant that the percentage of real word stimuli for which valid data could be analysed from people with dysphasia was only 75% whilst an even lower percentage of non-word responses, 53%, was considered acceptable. One participant manifested a level of dysarthria which rendered nearly all of his responses unsuitable for the measurement of response time to be calculated. Consequently it was decided that both his data and that of his matched control partner be excluded from the study, leaving four participants in each of the two groups. These issues highlight the difficulties of using response time measurements as a practical means of assessment with this particular participant population.

An additional factor which may have affected the results arises from the variety of phonemes which comprised the onsets of the stimuli items. Those items with voiceless fricatives at their onset may appear to have longer response times than items starting with, for example, voiced plosives because the actual onset may not be heard. The choice of items which could be included in the stimuli set was limited by the demands of the many factors previously described, frequency, regularity and body neighbourhood, consequently it was not possible to control for onset phonemes as well. However, the data set was sufficiently large that it is not anticipated that this issue has greatly affected the findings.

3.5.8.2 Comparison of Performance across the Participant Groups

The Mann-Whitney U-test was used to compare the performance of people with dysphasia and their matched controls. As predicted in the Similarity of Performance Hypothesis, the results indicated that the people with dysphasia performed significantly more slowly on all word types than the controls. There was no significant difference in their performance across word type. This shows that not only are people with dysphasia generally slower in their response to stimuli, but also gives an initial indication that the Similarity of Performance Hypothesis is supported and that they do produce a similar pattern of response times to those people with no reading difficulties.

3.5.8.3 Regularity

Analysis across regular and irregular words failed to uncover any significant difference in performance by either of the two participant groups.

3.5.8.4 Body Neighbourhood Results

To measure the performance of the two participant groups individually, by-item ANOVAs were used. The control group showed a significant difference in performance across the four neighbourhood word types ($p<0.0001$). A post hoc Scheffé test was used to determine which categories were responsible for this finding. The results showed that performance on unique words was significantly slower than on any of the other three groups. This difference was solely responsible for the ANOVA results. The same test was performed on the data from people with dysphasia. An identical, significant result ($p<0.0001$) again indicated a difference in performance across the body neighbourhood groups. A Scheffé test revealed that unique words were again responsible for the findings.

However, closer investigation of the response time results suggests that although both groups perform most slowly on unique words, their general performance shows some differences which are worthy of note. Table 3.1 shows both groups' mean response times to the four types of stimuli, measured in milliseconds (ms).

Table 3.1: Mean Response Times

Word Type	People with Dysphasia (ms)	Control Participants (ms)	Difference (ms)
consistent	1548.46	920.72	627.74
inconsistent	1587.58	925.60	661.98
exception	1604.57	918.59	685.98
unique	2453.48	986.30	1467.18

Although both groups performed most slowly on unique words, the pattern of performance was not the same on the other three groups. For the control group, exception words had the fastest mean response time, above both consistent and inconsistent words. For the people with dysphasia, consistent words were pronounced most quickly. This in itself might not be considered particularly important as for the control group the difference in mean response times across the three word types is only 7.1ms at its greatest. However, in the case of the people with dysphasia the difference is greater, with 56.11ms between the average response times to consistent and exception words.

A further difference is shown in the final column of Table 3.1. In order to be able to claim that the pattern of performance of people with dysphasia and their matched control partners is similar, the figures in the final column would have to be roughly equal. If the figures were the same then this would show that although people with dysphasia are slower at responding to stimuli, they are consistently slower. However, although there is less than a 60ms spread across the first three word types, there is a 782ms discrepancy between the unique word performance difference and the next greatest difference, exception words. These figures show that although the results of the statistical analyses appeared to indicate that the two participant groups performed in a similar manner, that this was not actually the case and that the people with dysphasia found the unique words disproportionately more diffcult.

3.5.8.5 Pseudoword Results

The same means of analysis were employed for pseudowords, significant differences in performance were found across non-word types for both participant groups ($p<0.0001$) and post hoc Scheffé tests indicated that in both cases, this significant result was due to poorer performance on the strange pseudowords.

The analysis was then performed again, this time in the absence of the strange pseudowords to see if any difference also existed across body type, that might have been obscured by the Strange Pseudoword Effect. In neither groups' data was any difference found.

3.5.9 DISCUSSION

Three hypotheses were formulated in relation to this experimental task. The Similarity of Performance Hypothesis stated that the performance of people with dysphasia would be slower than that of the matched-control group, but that such differences would be equal across all the word groups. The results initially appeared to support the hypothesis, as although the people with dysphasia were slower to provide a response than their control group peers, the two groups of participants did perform in a similar manner across the word types. However, closer investigation of this Body Neighbourhood Effect indicated that there were some differences in the performance of the two groups.

There were slight differences in performance across three of the word groups, but the biggest difference lay in the highly inflated response times of the people with dysphasia to the fourth group, unique words. The significance of this difference lies in its implications for the equating of response time and error scores across different studies. Even if, in the main study, the people with dysphasia show a similar pattern of errors to their peers in this investigation (i.e. they make more reading aloud errors on unique words than on any other type of neighbourhood category), it cannot be claimed that such findings can be directly correlated with the performance of the control participants. On the basis of the above evidence, control subjects and people with dysphasia do not show identical response patterns and therefore it does not seem that response times are necessarily reflective of numbers of errors. This finding suggests that although the performance of people with dysphasia may give a general indication as to mechanisms of normal functioning, it may differ in specific details. This issue will be discussed further in Chapter Six, when the findings of the main study are discussed.

The Word Type Hypothesis was not supported by the findings with regards to classification by regularity, as no significant differences were found in the response times to regular and irregular words. However, it was found that body neighbourhood does affect response time, as unique real words are pronounced significantly more slowly than words from any of the other three neighbourhood groups. Thus, the Word Type Hypothesis was supported by the body neighbourhood results.

In contrast, the response time pattern for body neighbourhood was not found to be maintained with regard to the pseudoword stimuli. This appears to be a preliminary indication that the Pseudoword Hypothesis is not supported. Classification by body neighbourhood appears to be appropriate for real words, but it does not have the same implications for pseudoword performance. It may be evidence of a difference in the methods by which real and pseudoword stimuli are processed, for example there may be additional factors affecting pseudoword processing which have a greater influence over their production than body neighbourhood.

Performance on the pseudowords may have been affected by the presence of the strange non-words and this may be responsible for the absence of any Body Neighbourhood Effects. The removal of strange pseudowords from the stimuli- set in the main study would remove the risk of any negative influence and indeed if a neighbourhood effect were then discovered in the main study this would indicate that they were in fact a distracting influence in this particular investigation. However, continued failure to find any such pattern would further support the suggestion that other factors are involved in pseudoword pronunciation.

Participants in the main study will be more familiar with the concept of pseudoword stimuli than their peers in this part of the investigation, as they will have already performed the Visual Lexical Decision Task which includes such stimuli, and this may increase their confidence in attempting to pronounce such items.

3.5.9.1 Methodological Implications for the Main Study

As well as providing experimental evidence with regard to response time patterns, this study had a number of aims relating to the proposed methodology of the main investigation:

a) **To investigate the practical issues involved in gathering response time data in the main study.**

There was little difficulty in actually collecting the response time data and although the equipment was somewhat unwieldy, it would be possible to collect such data in the homes of participants where necessary. However, the practical difficulties which occurred in the processing of the response time data from people with dysphasia (discussed in 3.5.8.1) suggest that the collection of such data throughout the tasks of the main investigation would not necessarily be a productive approach. It is anticipated that the number of errors will be more informative than any further response time data.

The participants who acted as controls in this study made very few actual reading aloud errors and therefore it is not considered useful to collect further data from them. However, comparisons will be made between their performance on the response times study and the error scores of participants with dysphasia in the main investigation in order to identify any relevant similarities or differences.

b) **To ensure that participants with dysphasia could cope with the volume and nature of the stimuli.**

It was decided that strange pseudowords should be removed from the stimuli set as people with dysphasia found them especially difficult to process and the large amount of missing data affects the reliability of the statistical analysis. In addition, their presence may affect the results which were obtained on the rest of the pseudoword data and there is no real word equivalent category with which to compare them.

c) **To monitor the suitability of the proposed inclusion and exclusion criteria for identifying participants for the main study.**

The results of the study suggested that the proposed inclusion and exclusion criteria for participant identification were both necessary and sufficient. However, the manner in which the mild motor speech difficulties of one of the people with dysphasia affected the data collected, (to such an extent that it was finally decided to exclude his data from the entire study), suggests that rather than relying on information from a speech and language therapist that a person has no significant dysarthria, a Frenchay Dysarthria Assessment (Enderby, 1983) should satisfactorily completed by all potential participants before admitting them to the main study. The confusion may have arisen over what qualifies as significant dysarthria as in normal speech the participant concerned in this study spoke sufficiently clearly to always be able to make himself easily understood. However, in the case of the response time study, any level of dysarthria affected the data collection process. To ensure that no similar issues should arise with regard to any visual difficulties, it was also decided to ask each patient to complete the visual acuity task from the Arizona Battery for Communication Disorders of Dementia (Bayles & Tomoeda, 1993) test battery prior to any other data collection.

3.5.9.2 Summary

This study has indicated that body neighbourhood may indeed be a relevant factor in the successful processing of real words by people with dysphasia. However it also shows that caution should be employed when comparing such results with those obtained from normal participants. It appears that factors other than body neighbourhood may affect the production of pseudoword stimuli and consequently, to reduce the risk of potentially irrelevant influences, strange pseudoword stimuli were omitted from the main investigation. The practical difficulties involved in processing response time data from people with dysphasia led to the decision to collect no more data of this nature and minor adjustments were made to the inclusion and exclusion criteria for potential participants to ensure that further difficulties in processing the data were avoided. The methodology for the main study can now be fully established and data is available to enable the comparison of the response time data and errors of people with dysphasia.

CHAPTER FOUR: MAIN STUDY METHODOLOGY

4.1 INTRODUCTION

In this chapter, the tasks which were employed to address the aims of this study are described. Details are given of the rationale for including specific tasks, as well as details of their construction, execution and the type of data analysis undertaken. The tasks are discussed in the order in which they were undertaken by the participants:

- Visual Lexical Decision (**VLD**)
- Reading Aloud (**RA**)
- Reading For Meaning (**RFM**)
- Repetition

Based on the research questions (c.f. 1.2), the tasks shared the common aims and hypotheses which are stated below. Some of the tasks had additional specific aims and hypotheses and these are given in the pertinent sections of this chapter.

4.1.1 AIMS

The aims of this study (as previously stated in Chapter One, c.f. 1.3) were to produce data with which:

- To provide detailed evidence of the origin of reading aloud errors displayed by adults with dysphasia.

- To investigate the underlying nature of these errors by considering both their type and the subjects' comprehension of the words which they read aloud incorrectly.

4.1.2 HYPOTHESES

- **Frequency and Word Classification Hypothesis**

  In the literature review it was shown that when investigating word classification as an indicator of (un)successful pronunciation, some researchers have focused on the application of the regular-irregular dichotomy whilst others have considered the use of body neighbourhoods. No studies are reported which compare the two methods simultaneously, so here it is proposed that *there will be a pattern of incorrect responses which can be most effectively explained by one of the identified methods of word classification in combination with word frequency* (a factor universally recognised as affecting word recognition and production).

- **Pseudoword Hypothesis**

  Based on the findings of Glushko (c.f. 2.4) and the single route principle which states that words and pseudowords are distinguished only be functional properties of the system (c.f. 2.5.1.3.), it is hypothesised that *the pattern of incorrect responses on pseudowords and pseudohomophones will reflect the pattern of responses to the real word stimuli*

- **Task Hypothesis**

  If an effect of stimuli type can truly be claimed to be due to the inherent nature of the stimuli and not simply reflective of the influences of any given task, then it is predicted that *any word or pseudoword effects will be constant across the tasks.*

4.2 VISUAL LEXICAL DECISION (VLD)

4.2.1 INTRODUCTION

Only brief reference was made to the lexical decision task in the main literature review, so a full discussion of the issues pertaining to it is provided in this chapter.

4.2.2 LITERATURE REVIEW

4.2.2.1 Introduction

The visual lexical decision task requires participants to look at a series of written stimuli and respond either "yes" or "no", depending on whether or not they believe the item to be a real word. Coltheart (1981) claims that success at lexical decision indicates an intact word recognition system. It is generally assumed that access to the lexicon must occur prior to any such successful word recognition (Coltheart, Besner, Jonasson & Davelaar, 1979), for example when determining whether or not a legal pseudoword is a real word, and consequently the lexical decision task is frequently invoked both as an experimental task to investigate how lexical access is achieved (Coltheart, 1978) and as a diagnostic device to determine the level at which the mechanism is capable of functioning.

By manipulating the stimuli, i.e. by using different types of words or pseudowords (Parkin and Underwood 1983, Waters and Seidenberg 1985), or by altering the means of presentation e.g. using priming or masking (Grainger, 1983; Monsell,

1991) it has been demonstrated that a number of different aspects which may influence visual word recognition, such as frequency and regularity, can also be investigated. However, there is some contention over the intrinsic value of the lexical decision task compared to the pronunciation task. Balota and Chumbley (1984) are of the opinion that the decision stage provides exaggerated estimates of the frequency effect, which cannot occur to the same extent during the pronunciation task as it omits the conscious decision stage. Paap and Noel (1987) argue that this is not in fact the case and rather that word pronunciation underestimates the frequency effect. Andrews (1982) accepts that the VLD task shows an enlarged frequency effect, but still maintains that it is a more valuable task because it requires lexical access without the additional complexity of the letter string having to be pronounced and this view is wholly supported by Hildebrandt and Sokol (1993) who argue that the pronunciation task requires the use of a number of skills which might confound the results. Andrews (1989) concludes that the best solution is to investigate the stimulus variables in a number of different tasks as this may provide additional rather than conflicting information as to the origin of the observed effects. This is the approach that has been followed in the current investigation, so the findings of the visual lexical decision task are considered not only in their own right, but more particularly in relation to the results of the other tasks. Indeed, the purpose of this investigation is not to study the mechanism of lexical access per se, but rather to identify which categories of words might be most easily accessed in an impaired lexical reading system.

4.2.2.2 Response Time Measurements Versus Accuracy

Much of the concern about the exaggeration of effects such as frequency in the VLD task relates to the results of investigations which focus on the speed rather than the accuracy of responses. Many VLD studies have collected data only from young, neurologically unimpaired participants who are unlikely to make many mistakes and therefore, in order to gather any meaningful information about normal processing, it has been necessary to consider the speed of their responses. However, concentrating on speed of response risks speed-error trade-offs, whereby the more quickly participants respond the more errors they appear to make (Harley, 1995) thereby contaminating the accuracy data. This would appear to be particularly true of people with dysphasia as Cermak, Stiassny and Uhly (1984) report that such participants have proven to be particularly poor at making lexical decisions because they are unable to manipulate the stored features of words for comparison purposes with the same speed and efficiency as their unimpaired counterparts. Their responses on speeded lexical decision may therefore be so affected by the time restrictions that it is not possible to draw definite conclusions about the effect of other variables, such as frequency and word type, on their performance. This fact, combined with the difficulties that were encountered with this population in the Response Time task led to the decision that, in this study, more informative data could be collected in the absence of time pressure.

4.2.2.3 Mechanisms Of Lexical Decision

VLD is a signal detection task in which participants must establish criteria for deciding whether or not a stimulus is a word (Seidenberg, Waters, Sanders and

Langer, 1984). In an attempt to explain how such a decision is made, Balota and Chumbley (1984) propose that words and pseudowords can be discriminated on a familiarity/meaningfulness (FM) dimension. A particular letter string's value on the FM scale is based on its similarity, both orthographic and phonological, to actual words in the lexicon. Some word targets are much more easily discriminable from pseudowords than others, and vice versa. Two criteria are therefore set, a high criterion above which few pseudowords will be likely to rise and a low criterion below which not many real words will fall. It is proposed that the level of these criteria will be determined by the similarity between the words and pseudowords on the stimuli list. Three sources from which errors might be derived have been identified:

1. **When a real word has a very low FM value or a pseudoword has a very high FM value.**

   There are two types of real word which might be predicted to have a particularly low FM value - those which have very unusual spellings and therefore do not much resemble the majority of real words and those which are less common and are therefore less familiar to the participant. Pseudowords which look or sound like real words will have a higher FM value compared to more unusual pseudowords, pseudohomophones might therefore be particularly likely to have a higher FM value.

2. **When there is a lack of knowledge about the appropriate spelling of a word.**

   In this case the participant must guess and some level of error is unavoidable.

3. **If the participant has established a criterion time after which a guess will be made if they are unsure.**

This factor would really only be relevant to those studies primarily interested in response time when a slower response times might suggest that the participant was guessing. It seems most likely that the stimuli types affected by this are those which are also most influenced by the previous two factors.

Words which the participant does not know and therefore does not have stored in either the orthographic or phonological lexicon will be prone to errors as participants will be likely to guess their lexical status. It seems reasonable that the participants would make such a guess based on the items' orthographic and phonological similarity to real words. However, there is some debate as to which components are most influential in determining whether an item is more or less word-like in terms of the decision criteria. According to proponents of the dual-route model the most likely unit of influence is the grapheme, however Treiman and Chafetz (1987) found that body units are particularly salient in this task.

How participants might go about setting their criterion time, particularly in non-speeded tasks where the maximum time is not already determined for them, is also an issue which needs to be considered. Waters and Seidenberg (1985) insist that criteria may vary across VLD tasks depending on factors such as the discriminability of word and pseudoword stimuli and the nature of the instructions given to the participants. However, it seems improbable that the criteria can be set to suit a particular list as participants generally have to make their decisions without having seen the whole stimulus list. One advantage of including practice items at the beginning of a task may be that it gives participants some standard of difficulty by which to determine their criteria thus reducing the likelihood of random responses.

Paap and Noel (1987) question the validity of the FM model as they claim that it implies that word recognition occurs without any reference to the lexicon. In fact no such suggestion is made, rather it appears that the FM rating of a word will simply influence the time it takes to retrieve it or, in the case of a pseudoword or unknown word, the time it takes to realise that no representation of it is stored in any way.

4.2.2.4 Processes of Visual Word Recognition

The FM rating system appears to allow for the influence of both orthography and phonology in the decision making process, however it does not specify by what mechanisms these factors are employed nor how they might, or might not, interact with each other to reach a satisfactory conclusion as to the lexical status of an item.

According to dual-route theory, a decision can be achieved by one of two means:

1) Visually - by using the visual properties of the component letters or whole word, the lexicon is searched until an *orthographic* match is found.

2) Phonologically - the printed word is phonologically encoded and then the lexicon is searched to find a *phonological* match.

The suggestion that the two routes of dual-route theory compete with each other, with the quicker route being the more successful (Paap and Noel 1991), has already been discussed at length in Chapter Two. It has been suggested that the same occurs in the lexical decision task (Meyer, Schvaneveldt & Ruddy, 1974). The visual route is the less complex of the two, as it requires fewer mechanisms to achieve lexical access and so it has been predicted that the visual route would achieve lexical access more quickly (Andrews, 1982).

With reference to the competition between the two routes, Coltheart et al. (1979) proposed that when the letter string is a real word, the visual route always completes lexical access, and therefore recognition, before the phonological route. Hence, positive responses are always generated by the visual route. For pseudowords phonological coding is completed more quickly than visual route processing, because any orthographic attempt at lexical access will require the entire lexicon to be searched before reaching the conclusion that the item is not actually present.

The visual route could successfully reject pseudowords, although it would take a considerable amount of time, and therefore it could be argued that the visual route is sufficient to perform the lexical decision task without the involvement of any other route. However, evidence from different types of pseudoword processing refutes this suggestion. For example, it has been shown that pseudohomophones e.g. *brane* take longer to process than pseudowords which do not sound like real words e.g. *goap*. This is termed the Pseudohomophone Effect and this finding has been taken to suggest that phonological processing must be occurring in VLD, at least for pseudoword identification. The Pseudohomophone Effect was challenged by Fredrikson and Kroll (1976) and they subsequently concluded that lexical access, in this task at least, was performed on a visual rather than a phonological basis.

However, although it is clear that the phonological route cannot work effectively in isolation - only the visual route could conclude correctly that *brane* is not a real word (Parkin, 1982) - more recent experiments suggest that the Pseudohomophone Effect does occur and therefore it would appear that both the visual and phonological routes are involved in the process of visual lexical decision.

Such cooperation between the two routes is the most viable means of dual-route functioning and the time-course model of Waters and Seidenberg (1984) would appear to be the most efficient at describing how this might happen. Orthographic units are said to be derived from the input and as they are identified their phonological representations are encoded. A word will then be recognised when its entry in the lexicon becomes sufficiently activated to achieve threshold value (c.f. 2.3.4.1). As orthographic processing occurs in advance of phonological encoding it will, in the cases of easily accessible real words, be the successful route. The phonological route will succeed when the visual route is unable to identify the target item - presumably in the case of pseudowords and highly infrequent or unfamiliar words.

Rastatter & McGuire (1992) investigated whether cerebral organization for visual linguistic processing alters with advanced age. They proposed that significant increases in the amount of time required to perform lexical decisions indicate that an alternate processing strategy may have been employed, specifically she suggests that lexical access might have been phonologically mediated. Lexical access is, as has been described, generally direct (based on orthography), but if this is not possible in the elderly then they may have to rely more heavily on phonology, therefore the lexical decision becomes more complex and more errors may occur as a result.

Evidence from Allen, Madden, Weber and Groth (1993) supports Rastatter and McGuire's (1992) findings. They found that as word encoding (phonological) difficulty increased so older adult performance scores decreased. This implies that phonological encoding is heavily involved in lexical decision, at least in the older population. If this is indeed the case and the elderly do use the phonological route without reference to the visual route, then it would seem that the time-course model is not correct after all, or at least it is not applicable to older adults. Such findings might explain why a regularity effect was found in some studies, but not in that of Coltheart (1978) which used much younger participants. These findings also add further weight to the argument that speeded lexical decision is not appropriate to the purposes of this investigation, involving as it does an older population with neurological damage.

The ability to perform the visual lexical decision task is one aspect of word processing which the connectionist single-route models have not concentrated on reproducing. In the meantime, Coltheart et al. (1993) insist on viewing this lack of application as an indictment of the failure of the SM89 model and other similar connectionist models to validly reproduce some of the skills required of a model of reading aloud (c.f. 2.5.2). This is not necessarily a matter of any great concern in terms of the application of single-route theory, as single-route models have not yet tried to simulate performance of this task. The theory itself may as yet be unable to explain the processing mechanism, however this does not diminish the value of an investigation of the effect of body neighbourhoods on the performance of the task. If anything, a positive result in favour of body neighbours as a dominant means of word storage would indicate the value of pursuing the single-route approach to letter string classification.

4.2.3 AIMS

In addition to the general aims (4.1.1), the VLD task had a particular methodological aim:

- To familiarise participants with the concept of pseudowords and pseudohomophones in preparation for the reading aloud task.

4.2.4 HYPOTHESIS

- **The Pseudohomophone Hypothesis**

It is argued that pseudohomophones are likely to have a higher FM value than pseudowords (c.f. 4.2.2.3) and that consequently a Pseudohomophone Effect occurs (c.f. 4.2.2.4), thus it is hypothesised that *participants will be less successful in recognising pseudohomophones as non-word items.*

4.2.5 STIMULI

The stimuli used in this task were:

- 52 real words representing the different combinations of frequency, regularity and word body
- 33 pseudowords which shared the same bodies as the real words above.

- 24 pseudohomophones which shared the same bodies as the real and pseudowords above.

The stimuli were divided into four sets so that no two stimuli with the same body were in the same test group (See Appendix Two). This was again an essential element of the task design so that inter-list priming could not occur. To prevent intra-list priming, tests were presented at weekly intervals wherever possible. Occasionally, this was not possible due to availability of the participants. In these instances, participants were required to perform a distracter task between lists to reduce the likelihood of any priming occurring.

4.2.6 TASK ADMINISTRATION

This task was the first to be carried out as all other tasks clearly divide the stimuli into real and pseudowords and could thus have primed participants' responses. Before beginning each sub-section the participants were shown a practice real word and pseudoword sample, the differences between the two were discussed with them in terms of their being familiar with the real word, but not the pseudoword. Participants were then asked to study each test item carefully and then pronounce either "yes" or "no" depending on whether they thought it was a real word or a "pretend" word. They were instructed only to look at the stimuli and were requested not to attempt to pronounce them. Where necessary they were reminded of this throughout the task.

4.2.7 TASK ANALYSIS

As has already been discussed, this task was to be considered purely in terms of numbers of errors and not speed of response. Total errors on each type of stimulus were counted for each participant and analysed using MANOVAs, to determine which, if any, specific category of items proved particularly difficult for participants to identify correctly. Cross comparisons could then be made with the results from the Response Times study.

4.3 READING ALOUD (RA)

4.3.1 INTRODUCTION

As the main body of the literature review dealt largely with issues specific to the reading aloud of single words, there is little more to discuss at this point. However, it should be noted that the pronunciation task may be deceptive in its simplicity (Balota & Chumbley, 1984) and therefore the results are best considered in the light of results from other tasks using identical stimuli (Andrews, 1982). One potential source of difficulty with the pronunciation task is that it requires overt pronunciation and therefore participants must access phonological information which might not be used in silent reading (Waters & Seidenberg, 1985). However, this may not be a relevant issue if, as the time-course model suggests it is assumed that phonological code activation occurs automatically after decoding. The retrieving of a phonological code is not task-dependent, but rather is dependent on the time course of the process, so it is not anticipated that the results of this task would be disadvantaged by the pronunciation aspect of the naming procedure. The aims and hypotheses relating to this task are the ones given at the start of this chapter (c.f. 4.1.1/4.1.2).

4.3.2 STIMULI

This task involved all the real and pseudowords in the test battery (c.f. Appendix One).

4.3.3 TASK ADMINISTRATION

Stimuli were sub-divided as in previous tasks to prevent both inter- and intra-list priming. Practice items were presented at the beginning of each session to demonstrate to the participants the nature of the stimuli which they would be encountering. In the case of the pseudoword stimuli, participants were clearly told that the items were "made up" words which they would not know and that they should treat them as if they were simply new words which they had never met with before. They were advised that there was no right or wrong way to pronounce the items and that they should make what appeared to them to be a reasonable guess as to their pronunciation.

4.3.4 TASK ANALYSIS

This task was also to be considered in terms of numbers of errors and not speed of response. Total errors on each type of stimulus were counted for each participant and analysed using MANOVAs, to determine which, if any, specific category of items proved particularly difficult for participants to read aloud correctly. Cross comparisons could then be made with the results of the Response Times Study and from the Visual Lexical Decision Task.

4.3.5 ERROR TYPES

As well as recording the number of errors which participants made, the purpose of this study was to also consider the nature of those errors and attempt to determine whether there was any pattern of error types across the different word classifications which would prove to be clinically informative.

4.3.5.1 Introduction

There has been a considerable debate concerning the usefulness of investigating error types. Shallice (1988) considers the analysis of errors to be fruitless in terms of generalising across people with dysphasia and Marcel (1980) argued very strongly against the approach of inferring modes of normal processing from errors supposedly made when using that method of processing (in much the same way that Coltheart demanded that disorders of reading should be described as atheoretically as possible), but this does not by any means make the investigation of error types and patterns a worthless pursuit in itself. Basso, Corno and Marangolo (1996) agree that clinical symptoms cannot be predicted by error type, but they also state that it is not adequate to consider responses only in terms of the number of errors. Indeed, Garrett (1992) proposes that one important form of evidence comes from the possible relations between the target word and the erroneous production. He suggests that lexical failure may provide clues that will enable further development of theories of language processing. Dell, Schwartz, Martin, Saffran and Gagnon

(1996) agree, they believe that the lexical retrieval errors of aphasic patients provide a valuable data source for theories of language processing. The errors may not point in the direction of a particular theory or diagnosis, but the success or failure of the theories to explain a particular pattern of errors may be very telling. Additionally, as Brooks (1977) indicates, another value of studying error types is that they may identify possible areas of remediation.

In their investigation of oral and written confrontation naming errors, Basso et al. (1996) found that error patterns change as the time post onset increases. They found that the same pattern of change held true for both written and oral naming, namely that both nil responses and neologisms decrease in number, whilst orthographic and phonological errors increase. This finding suggests that a greater understanding of the nature of error types may be useful in monitoring the progress of a person with dysphasia.

Marshall and Newcombe (1973) believed that identifying the nature of errors was an extremely important factor in the development of theories of reading aloud. However, they also indicate that it is important to be aware that errors are not uncommon in the normal course of reading aloud by skilled, adult readers with no neurological impairment. Garrett (1992) describes the *environmental intrusion errors* which occur in normal reading due to the constraints of memory and attention and although he states that it is unknown how these factors relate to aphasic error performance, there is no reason to suppose that they will not influence aphasic performance as they do performance in unaffected members of the population.

4.3.5.2 Visual Errors

Marshall and Newcombe (1973) consider visual errors as a peripheral dyslexia caused simply by a visual impairment or poor concentration. They propose that there are three types of visual error:

- Straightforward (misidentifications) e.g. *dug* → *bug*
- Word reversals e.g. *was* → *saw*
- Additions e.g. *lop* → *slob*

Coslett, Rothi and Heilman (1985) identify an additional type:

- Deletions e.g. *shore* → *sore*

Friedman (1988) disputes that visual errors are usually due to visual difficulties, but thinks that as they are present in practically all forms of alexia then they are of little use in diagnostic terms. Rather, she suggests that knowing the nature of the alexia may assist in understanding the underlying nature of the errors, for example people with surface alexia may have difficulty accessing word forms and an orthographically similar word may be activated by mistake; reading through the semantic route may also cause orthographic errors as in phonological alexia and, she suggests, even more strongly in deep alexia. Friedman (1988) also proposes that they should be more accurately termed orthographic errors as they generally share many letters with the target but do not necessarily share the visual features of shape and letter length. Coltheart (1981) uses the following as examples of the type of visual errors made by people with deep dyslexia: *gender* → *garden, letter* → *lettuce, moment* → *memory*. These seem only loosely connected to their targets, they follow the same basic word shape and letter length but are not orthographically very similar.

Not all misreadings by people with surface dyslexia are regularisations, some are letter deletions, additions, substitutions or letter-order errors (Coltheart, 1981), so it is suggested that rather than using GPC, people with surface dyslexia use an approximate visual strategy which enables them to select an orthographically similar entry in the word recognition system. However, Coltheart also accepts that this is likely to be an incorrect explanation as similar errors are made on pseudowords. It could of course be the theory rather than the explanation that is incorrect. According to Hinton and Shallice's account (1991), visual errors occur due to their network's inherent bias towards similarity, i.e. because it stores similar patterns closely together the possibility for error is great and presumably increased when the model's structure is damaged. Lesions which occur prior to the level of semantic processing lead particularly to visual errors as the error then occurs before feedback from semantics is able to reinforce the correct production (Plaut, 1995).

De Bastiani, Barry and Carreras (1988) considered that dual-route theory might explain visual errors as being due to the lowering of the thresholds of word detector units in the logogen system of the lexical route, hence visually similar lexicalisations might then occur. However as their participant showed good lexical decision between orthographically similar words and pseudowords they concluded that this proposal seems to be insufficient on its own to explain the profusion of such errors. They suggested that an analogous explanation might be more fitting to the data, proposing that conflict of orthographic segmentation and phonological assembly or disruption in the interaction of the two functions might be a better explanation. It is certain that it might be a better explanation, but it does not necessarily support analogy over dual-route as the explanation might equally apply to dual-route processing mechanisms, thus further supporting Marcel's (1980) warnings of the dangers of making theoretical inferences from errors.

Plaut (1996b) suggests that visual errors occur in networks due to the inherent bias of the network towards similarity. Visually similar words tend to produce similar initial semantic patterns which can lead to visual errors if the basins of attraction in this model are distorted due to lesions. Plaut and Shallice (1993) suggest that visual errors arise as a result of damage to the semantic attractors and thus are able to explain how, in deep alexia, abstract words are more likely to produce visual errors. Abstract words will have a much weaker semantic representation than concrete words so they are likely to be more vulnerable to any damage to the semantic attractors.

Morton and Patterson (1980) propose that a target and response must have at least 50% of their letters in common to be considered a visual error, e.g. *chief* → *chef*, a notion supported by many others (Coslett, 1985; Coslett, Heilman & Rothi, 1985; Caplan, 1987; Glosser & Friedman, 1990). This was taken as the standard definition for visual errors in this investigation.

4.3.5.3 Phonological Errors

Lecours (1982) described phonemic paraphasias as neologisms which can be described by reference to a positively identified target in terms of deletions, additions and/or displacement of phonemes. Generally, phonological errors are considered to be a separate entity from neologisms. To qualify as a phonological paralexia, reading aloud errors must be fluently produced, i.e. without apparent motor speech difficulty, consistent with phonotactic rules and contain the same number of syllables and stress contour as the target. In the case of the production being a pseudoword it must be sufficiently close to the real word target as to be identifiable in context, e.g. *beg* → *breg*.

Friedman and Kohn (1990) define a phonologically related attempt as a response that matches the target in terms of at least a consonant cluster, a stressed vowel or the onset and coda of a syllable. This was taken as the standard definition for this study.

4.3.5.4 Regularisations

Regularisations are defined as errors caused by treating irregular words as if they were regular (Ellis & Young, 1988), for example *sugar* → *sudger, broad* → *brode* (Ellis, 1993). Coltheart (1981) concludes that regularisations and comprehension issues can be explained in terms of a failure of visual reading and the subsequent reliance on phonological reading. However he concedes that such explanations do not hold for deletions. The value of considering error types in detail is highlighted by the results of Bub, Cancillerie and Kertesz (1985) who report that the regularisation errors of their participant (MP) indicate that his analysis of letter clusters is not restricted to grapheme units. They state that several of his errors indicate that entire word endings are used to assemble a response e.g. Humphreys and Evett (1985) suggest that there is little reason to consider incorrect GPC assignment errors as anything other than visual errors.

In response to the variation in definitions of regularisations, Shallice and Warrington (1980) differentiated between:

- Inappropriate applications of correspondence rules where rules are correctly applied resulting in alternative pronunciations/regularisations.
- Partial failures of GPC rules e.g. *resent* → *rissend.*

4.3.5.5 Legitimate Alternative Reading of Components (LARC Errors)

In this type of error, the pronunciation of the whole word unit is incorrect, but the pronunciation of each character (grapheme) is legitimate (Patterson, 1995). She describes regularisations as the quintessential LARC errors, but whereas only irregular words can be regularised, all types of words are participant to LARC errors e.g. regular word *hoot* pronounced to rhyme with *foot.* Irregular words can also yield LARC errors which are not regularisations, for example the regularisation of *tomb* would rhyme with *comb* but it can also be pronounced to rhyme with *bomb.*

4.3.5.6 Neologisms

Lecours (1982) originally classified three types of neologism:

- Phonemic paraphasias
- Morphemic deviations
- Abstruse neologisms

It is this third class that was considered true neologisms in this study as the other two categories bear their own definition under the headings phonological and derivational paralexias respectively. Neologisms are generally defined as pseudowords that cannot be recognised as straightforward visual, phonological or other types of distortions of a real word target (Basso et al., 1996), for example *both* → *blukts, butterfly* → *bowdlfley* (Ellis and Young, 1996).

Ryalls, Valdois and Lecours (1988) identified three characteristics which provide an empirical definition of neologisms in single word reading:

- They are word-like entities which are not listed in the dictionary.
- The organisation of phonemes and syllables abide by the phono-tactic conventions of the speaker's native language.
- The response cannot be identified as a phonemic paraphasia.

It is the above characteristics that were used as the defining factors in this study.

4.3.5.7 Semantic Paralexias

Semantic paralexias are always real words and are defined as a word which is semantically or associatively related to the target word (Caplan, 1987). For example for the target *swan*, patients may retrieve the semantically related *duck* or the formally related response *swim* (Dell, Schwartz, Martin, Saffran, Gagnon, 1996).

4.3.5.8 Derivational Errors

Marshall and Newcombe (1973) suggest that derivational errors may be another type of visual error. This is supported by Funnell (1987) who found that morphological errors were as influenced by frequency and imageability as non-morphological errors and therefore she concluded that they were simply a type of visual error. Shallice and Warrington (1975) thought it possible that they were related to other semantic paralexias as did Allport (1987) and Coslett, Heilman and Rothi (1985) who describe them as derivational-semantic errors in which the word produced is similar semantically and has the same root morpheme as the target e.g. *who* $\rightarrow$ *whose*. Friedman (1988) may be supporting this when she describes how such errors are always produced by people with dysphasia who also produce semantic paralexias. However, although the errors in this category are both visually and semantically related they are best considered to be a separate class (Ellis, 1993). They are much less open to misclassification than other categories of error and thus are easily recognised. It is suggested that derivational errors often lie in the direction of returning the target to its root form e.g. *mastery* $\rightarrow$ *master, paid* $\rightarrow$ *pay* (Coltheart, 1981), however this is not always the case e.g. *child* $\rightarrow$ *children*.

Ellis and Young (1988) suggest that there may be some problems in deciding how morphological errors should be interpreted. They explain that it could be argued that in normal reading, written words are decomposed into their component morphemes before the visual input lexicon is accessed. If this were the case, then people with alexia might be said to have difficulty with bound morphemes and therefore tend to omit or substitute them when reading aloud. Indeed, Morton and Patterson (1980) suggest that it is an impairment of the linguistic processor which is sensitive to affixes whilst Caramazza et al. (1985) claim that there is a separate deficit of the morphological processing system. However, in opposition to this theory, Ellis and Young (1988) cite the fact that many people with alexia make visual and semantic paralexias as well and that morphological errors may just be a consequence of this. They consider that the evidence is not sufficiently clear as to enable them to determine which is the correct interpretation.

For the purposes of this study, derivational errors were considered to be a separate class to semantic and visual errors.

4.3.5.9 Function Word Substitutions

As the name suggests, one function word is replaced with another which suggests that the reader knows at some level what sort of word he is aiming to produce e.g. *and* → *because* (Ellis, 1993).

4.3.5.10 Multi-Derivational Errors (MDE)

Errors which may be due to either visual or semantic factors, or indeed both, are fairly common in deep alexia (Garrett, 1992). These errors do not fit exclusively into any category because it is apparent that a number of processes may have contributed to the error and/or it is not precisely clear what had occurred (Kaufman & Obler, 1995). Ellis (1993) provides the following example, *when* → *chick*, where it is assumed that the patient has combined a visual error (*when* → *hen*) followed by a semantic error (*hen* → *chick*).

4.3.5.11 Stereotypies

These errors are best described as repetitive utterances of the same sequence of syllable(s) or word(s) in response to most of the stimuli (Basso et al., 1996). In order to be considered a **perseveration**, these persistent responses must occur when the stimulus which initially elicited the response is no longer present and another response to a subsequent stimulus has been given (Eisenson, 1984).

4.3.5.12 Unrelated Errors

It is necessary to be extremely careful when classifying incorrect responses as entirely unrelated to their target. Some responses which appear to have no connection with the target at all may actually bear a distant relation to it, e.g. *unicorn* → *house*, in this example the patient may have initially retrieved horse (Dell et al. 1996), such errors are described in section 4.3.5.10. In this study, unrelated errors were considered to be those where there is no link, however spurious, between the target and response e.g. *shoe* → *wall.*

4.3.5.13 Some Types of Errors may be Confounded or Confused with Others

Many errors described as regularisations by some could equally be interpreted as visual errors e.g. *bear* → *beer* described by Nickels (1995) as a regularisation. This notion is supported by Friedman et al. (1992) who found that all the errors they had classified as regularisations could also be considered to be visual errors.

Saffran (1985) illustrates how errors described as visual may also be phonological e.g. *lose* → *loss, check* → *cheek.* This is supported by analysis of many similar examples which can be found in the descriptions of error types by other researchers, for example, Lesser and Milroy (1993), *signal* → *single*, Marshall and Newcombe (1973) *on* → *no*, Patterson and Marcel (1977), *while* → *white*, *scandal* → *sandals*, *polite* → *politics*, *badge* → *bandage.* Van Orden et al. (1990) state that the difficulty in differentiating between them lies in the fact that orthography and phonology are highly correlated. They states that no theory-neutral coding system has emerged that would discriminate between visual and phonological sources of error.

Errors which appear to be derivational might in some cases be simply visual misidentifications, Ellis and Marshall (1978) provide the example of *run* → *ran*, which might be derivational but could equally be a case of confusing the two underlined letters, for that matter the error might equally be a phonological substitution, although these are more generally confined to consonants.

4.3.5.14 Pseudoword Errors

Van Vugt, Paquier, Bal and Creten (1995) describe two types of pseudoword lexicalisations:

- Straight lexicalisations
- Lexicalisations which could also possibly be visual errors

Friedman et al. (1992) accepted responses to pseudowords as correct if all the consonants were pronounced according to any of their standard phonemic equivalents and if the vowels were pronounced according either to GPC rules or to that of an analogously-spelled word. They then coded error responses for the type of alterations that were made to the phonemic string e.g. vowel/consonant change, syllable changes, lexicalisation. Shallice, Warrington and McCarthy (1983) suggest that lexicalisations arise as a result of the reader's attempt to compensate for an impaired phonological route by using guessing strategies.

4.3.6 AIM

- To investigate whether or not type of reading aloud error is related to word type

4.3.7 HYPOTHESIS

- **Error Type Hypothesis**

  Garrett (1992) and Dell et al (1996) suggest (c.f. 4.5.3.1) that error types have important implication for theories of language, so it may be that there is some relationship between error type and word type. Hence, it is hypothesised that *error type will be influenced by word type.*

4.3.8 TASK ANALYSIS

The reading aloud errors were classified using the definitions given above. Two raters categorised the errors independently and then the results were compared to ensure that the classification was as objective as possible. Chi-squared tests were performed to determine whether or not there was any relationship between error type and word type.

4.4 READING FOR MEANING (RFM)

The semantic knowledge of dysphasic patients is frequently investigated by means of word-picture matching tasks, patients are given a number of pictures and asked to match the written word to the correct picture, or by judgement tasks in which they are required to determine which of three other words the target word is most like in meaning. The first method relies on all the words being imageable in nature, which is often not the case, and results from it may also be attributable to visual inattention or impaired object recognition as well as semantic deficit (Coslett, 1991). In order to avoid such influences, a reading for meaning (RFM) task which did not rely on picture or object based materials was devised with the aim of investigating whether or not participants were able to comprehend the meaning of the words which they had read aloud incorrectly.

As it seemed likely that participants would have different levels of dysphasic impairment, it was necessary that the task be designed in such a way as to allow all of them to perform at an optimum level (Webb, 1987). It was anticipated that some of the participants would be able to give a definition for the word in question, whilst others might be able to construct a sentence including the word to indicate that they understood its meaning by putting it in context. Participants with less spontaneous expressive language ability might struggle with such a demanding approach, but might be able to choose the correct option from a written list of definitions. Any one of these responses was considered an acceptable means of measuring participants' semantic knowledge.

It was therefore proposed that participants be asked in the first instance to provide a definition or sentence for an item and if they were unable to do this that they then be offered a choice of definitions. The first approach did not require the preparation of any additional materials, however it was necessary to produce definitions for each word in case the participants should need them. As many of the words had a number of different dictionary definitions, it was felt that the best way to obtain the most appropriate definition for this participant population was to ask a group of ten skilled Scottish adult readers to write a brief definition for each word. The majority consensus was then taken as the definition to be used in the RFM task. For each item three definitions, one correct and two distracters, were produced. These were matched for length and syntactic structure. Both the object-picture matching and judgement tasks described above include closely related semantic distracters in their options of partners for the target word and it was initially proposed that at least one of the two alternatives in the RFM task should be semantically related to the target. However, on reflection it was felt that devising such a task would take a considerable amount of time and research which perhaps was not justifiable as this element was not the main focus of the study. In addition, it would considerably increase the complexity of the task and, as the aim was simply to ascertain the participants' knowledge of particular words, it was decided that it was neither appropriate nor necessary to do this.

Lack of knowledge of a word should not necessarily mean that it would be pronounced incorrectly. Depending on whether one supports dual or single route theories, participants should be able to construct a pronunciation for any unknown word using spelling-to-sound rules or analogy with orthographically similar words respectively. Consequently, unknown irregular words would be given an incorrect regular pronunciation according to dual-route, whilst according to single-route theories an unknown exception word would be given a pronunciation matching that of its inconsistent body neighbours. It is for the words not known by participants that one might most expect to find these regularisation/LARC errors. Analysis was carried out to investigate the nature of the error types made on both incorrectly pronounced known and unknown words.

4.4.1 AIMS

- To ascertain if participants had any knowledge of the meaning or appropriate use of the words which they failed to read aloud correctly.
- To determine if the spread of errors across the different groups of words was the same for those items which were known to the participants and for those which were apparently unknown.
- To compare performance on unknown words and pseudowords.
- To investigate any relationship between error type and word knowledge.

4.4.2 HYPOTHESES

- **Unknown Word Hypothesis**

  A possible explanation for the occurrence of any errors would be lack of word knowledge, therefore it is hypothesised that *the majority of words which are read aloud incorrectly will be unknown to the participants*.

- **Word Knowledge and Word Type Hypothesis**

  The distribution of errors will differ across word type according to the presence or absence of word knowledge (c.f. 4.4, p.136).

- **Pseudoword and Unknown Word Hypothesis**

It is often argued that similar strategies are used to pronounce unknown real words and pseudowords (c.f. 2.4.1). Therefore, it is proposed that *error performance on pseudowords will mirror that of performance on unknown words*.

- **Word Knowledge and Error Type Hypothesis**

It is possible that certain types of errors may be more common depending on whether or not a word is known to the participant, e.g. visual and phonological errors might be expected to occur more frequently on known words whereas LARC errors might be more prevalent on unknown words. Consequently, the hypothesis states that *there will be a relationship between word knowledge and error type.*

4.4.3 STIMULI

The task included only real word stimuli. The definitions offered for each item are given in Appendix Three. The number of items tested varied for each participant, according to their performance on the reading aloud task. Participants were asked to perform the task on the first five high and low frequency words which they had read aloud correctly from each of the first two blocks of the reading aloud task and as many as possible of the words on which they had made an error, time permitting. This task was generally to be completed in one session, except in the case of participants whose number of errors was sufficiently large as to make it necessary to split the task over two occasions.

4.4.4 TASK ANALYSIS

Initially it was intended that participants' responses be scored differently depending on whether they were able to provide a definition for, or a sentence containing, the target word, if they were able to identify the correct definition from the choice of three alternatives, or if they were unable to show in any way that they understood the word in question. However, the aim of the task was not to assess the extent of the participants' expressive abilities, it was simply to ascertain if they knew the meaning of the words which they were unable to read aloud correctly. Consequently, their responses were scored as either correct if they knew the word, regardless of the mechanism which they used to demonstrate this knowledge, or incorrect if they failed to correctly identify its meaning.

The items which had been read aloud incorrectly were then divided into those which participants knew the meaning of and those which they did not and the analyses that had been performed on the error scores as a whole were repeated on the two separate groups to determine what, if any, differences existed between the pattern of performance.

Before the above analysis was carried out, participants' RFM responses to the test words which they had read aloud correctly were checked to ensure that they were able to demonstrate knowledge of the words which they had read aloud correctly. Any failure to do so would have questioned the usefulness of the RFM task. If participants had been unable to demonstrate this knowledge, then it would have indicated that the RFM task failed to actually test the relevant semantic knowledge, or that lack of word knowledge did not affect the ability to read aloud. If the latter were true, then the findings of the RFM task would be irrelevant to the understanding of reading aloud ability. However, as all the participants showed full understanding of the test items which they had read aloud correctly it was considered that the results of the RFM task were relevant to the findings of the wider study.

4.5 REPETITION

The aim of the repetition task was to ensure that none of the participants had any difficulties with the stimuli at the level of the phonological output lexicon. Poor repetition skills might suggest that any reading aloud errors, particularly phonological ones, were indicative of general difficulties with phonological output rather than with the stimuli per se. This task was the last task to be carried out so that it did not influence patients' performance on any earlier tasks, particularly the RA task. Patients were asked to repeat thirty items of both the word and pseudoword stimuli including some items which they had produced incorrectly in an earlier task. It was not considered necessary that participants repeat all the words which they had read aloud incorrectly, as any difficulties with repetition would be expected to manifest themselves within a subset of the stimuli.

4.5.1 TASK ANALYSIS

A phonetic transcription was made of all the participants' responses and matched to that of the target responses to ensure that pronunciations were correct.

4.5.2 RESULTS OF THE REPETITION TASK

All the participants were able to repeat all the real and pseudoword items which they had read aloud incorrectly, with the exception of Participant 13 who did make some errors on items which had a voiceless fricative onset. These errors were clearly due to a hearing impairment. So, it was concluded that the errors which the participants made on the RA task were not due to difficulties at the phonological output lexicon.

4.6 SUMMARY

Four tasks have been described in this chapter. The results of the repetition task are given above (4.5.2), the results of all the other tasks are given in Chapter 5 and discussed in Chapter 6.

CHAPTER FIVE: RESULTS

5.1 INTRODUCTION

In Chapter Four a series of four tasks was discussed: Visual Lexical Decision (VLD), Reading Aloud (RA), Reading for Meaning (RFM) and Repetition. The findings of those investigations will be presented in this chapter, with the exception of the last task, Repetition. Repetition was included in the test battery purely to ensure participants' suitability for the study and the results of this task can be found at the end of Chapter Four. At the beginning of this chapter brief details will be given of the error counts of each of the participants on the VLD and RA tasks in order to provide a general overview of how individual performance may have contributed to the results being described. Data relating to the performance of individual participants will also be referred to throughout the chapter.

The results of the various investigations will not be presented in a chronological task-by-task manner, instead the findings for each word classification paradigm will be described in turn across all the tasks. So, for example, the effects of word frequency on performance will be reported in terms of findings from the VLD, RA and RFM tasks, followed by the effects of regularity, then the effects of frequency and regularity combined and so forth. The reason that this approach has been chosen for the presentation of the results is that the emphasis of this study is not on the *tasks* that are used to investigate reading aloud and its associated skills, but rather on the effect of the *nature of the stimuli* employed by those tasks. Findings relating to performance on pseudowords e.g *goap* and pseudohomophones e.g. *poap* are also discussed and are compared to the real word findings. A further section summarises the results of performance on each individual task and provides an inter-task comparison. A discussion of error types and how any pattern of such errors might relate to the findings of the previous sections is then presented.

5.2 STATISTICAL NOTES

Due to the variety of methods by which the stimuli could be categorised, it was not possible for every sub-classification to contain the same number of items in each of its groups. Consequently, in some parts of this chapter, percentage scores are presented instead of the raw data in order to allow comparisons across data-sets which contain different numbers of stimuli. In instances where statistical tests have been employed, scores have first been converted to a common base, again in order to compensate for the uneven group sizes and to ensure that the results are meaningful.

MANOVAs and t-tests were the statistical tests most frequently used to obtain the results described in this chapter. Unless otherwise stated, these tests were always performed as matched sample tests and all analyses were by-subject analyses. To compensate for the number of multiple t-tests which had to be performed after the MANOVAs, Bonferroni's correction was applied. Bonferroni corrected p-values are identified in ***bold italic*** script throughout the text.

5.3 PARTICIPANTS

It was originally intended that a minimum of twenty participants be recruited for the main study. However, the strictness of the inclusion criteria made the identification of suitable participants difficult and this, combined with the withdrawal of some participants from the study for personal reasons, resulted in a final total of fourteen participants.

These participants were recruited through speech and language therapists in both the Lothian and Borders regions and also through local Chest, Heart and Stroke Association community stroke groups. Potential participants were given an information sheet detailing the aims of the study and what would be required of them. Both participants and their carers were required to sign a consent form to acknowledge their understanding of this information and to indicate their willingness to take part in the study. Participants were seen either in the clinic at Queen Margaret College or in their own homes, according to their personal preference. All the participants attempted to perform all of the tasks. However in some instances they were unable to complete them and therefore their data was not included in the analysis of that particular task.

Table 5.1: Participant Details

Participant	Gender	Age	Post-onset CVA (Years)	AQ
1	M	63	1.2	80
2	M	67	5.3	78
3	F	68	3.2	88
4	M	58	2.1	92
5	M	64	4.2	82
6	F	79	6.4	86
7	F	61	2.5	68
8	F	55	1.1	80
9	M	60	3.5	90
10	F	65	5.5	884
11	M	60	3.0	76
12	F	59	4.1	74
13	F	78	5.2	66
14	M	45	2.1	70

There were seven male and seven female participants. All of them were at least one year post-onset of their CVA and, with the exception of Participant 14, they were all at least 55 years old at the time of testing. The Aphasia Quotient (AQ) of all the participants was measured using the Western Aphasia Battery (WAB), (Kertesz, 1982). All the participants ahowed a mild-moderate level of dysphasia, with scores ranging from 66-92.

5.4 OVERVIEW OF INDIVIDUAL PERFORMANCE (VLD & RA)

Table 5.2 shows the raw data and percentage scores of each participant on the VLD and RA tasks. The percentage of errors on the VLD task ranged from 3.8% to

34.6%. There was considerably more variability in performance on the RA task, with percentage of errors ranging from 2.6% to 50%. Individual performance both on and across the tasks will be discussed in greater detail throughout the chapter.

Table 5.2: Performance of Individual Participants (VLD & RA)

	VLD		RA	
Participant	**Errors**	**% Errors**	**Errors**	**% Errors**
1	16	30.8	29	12.7
2	2	3.8	22	9.7
3	7	13.5	11	4.8
4	5	9.6	6	2.6
5	6	11.5	20	8.7
6	2	3.8	13	5.7
7	18	34.6	79	34.3
8	8	15.3	16	7
9	2	3.8	7	3
10	13	25	115	50
11	11	21.2	36	15.7
12	8	15.4	39	17
13	15	28.8	112	48.7
14	15	28.8	75	32.6
Mean Errors	9.1	17.6	41.4	18

5.5 FREQUENCY

5.5.1 VISUAL LEXICAL DECISION

Recognition of low frequency words was significantly poorer than that of high frequency words ($t = 4.04$, d.f. = 13, $\mathbf{p<0.001}$).

5.5.2 READING ALOUD

A significantly greater number of the low frequency stimuli were also read aloud incorrectly ($t = 4.63$, d.f. $= 13$, **$p<0.001$**).

5.5.3 READING FOR MEANING

5.5.3.1 Known Words

Statistical analysis on those words of which subjects knew the meaning, but still read aloud incorrectly, gave a similar result to that of the data set as a whole. There was still a strong significant effect of word frequency ($t = 4.35$, d.f. $= 13$, **$p<0.001$**), demonstrating that reading aloud performance on low frequency words remained less good than that on high frequency words.

5.5.3.2 Unknown Words

Analysis of performance on the words which were read aloud incorrectly and which appeared, according to the RFM task, to be unknown to the readers showed that there were significantly more low frequency words of this type, ($t = 2.99$, d.f. $= 12$, **$p<0.01$**).

5.5.4 SUMMARY OF THE FINDINGS RELATING TO FREQUENCY

45% of the low frequency words which were read aloud incorrectly were unknown to the readers, compared to only 28% of the high frequency words which were read aloud incorrectly, so it is possible that lack of lexical knowledge may have played some part in the occurrence of a significant frequency effect. However, the fact that the frequency effect was also maintained across the group of words which participants read aloud incorrectly but knew the meaning of, indicates that it is not lack of knowledge of low frequency items alone that causes a poorer reading aloud performance on words of this nature.

Participants made a much greater total number of errors on words of low frequency. However, it is interesting to note that whilst 55% of those errors were made on words of which the readers showed some knowledge, in the case of high frequency words that percentage was considerably higher. Readers appeared to know the meaning of 72% of the high frequency words which they had read aloud incorrectly. This fact may be of particular interest when compared with the types of errors which were made on these items.

5.6 REGULARITY

5.6.1 VISUAL LEXICAL DECISION

Significantly more irregular than regular words were incorrectly identified as being pseudowords (t = 15.70, d.f. = 13, **p<0.007**). An ANOVA which investigated frequency and regularity together also yielded a significant result (F = 7.48, d.f. = 5.97, **p<0.001**). Table 5.3 shows the significant results of subsequent t-tests (where ***p<0.008***, Bonferroni corrected).

Table 5.3: Significant Results for Regular v Irregular Words by Frequency (VLD)

Word Type	**P-value**
regular high - regular low	0.001
regular high - irregular low	0.001
regular low - irregular low	0.002
irregular high - irregular low	0.005

All the above results can be attributed to an effect of frequency alone with the exception of the highlighted *regular low - irregular low* difference. This indicates that low frequency words with irregular spellings are mistaken for pseudowords significantly more often than any other word type within the combined paradigms of frequency and regularity. The absence of a significant effect between the opposing high frequency groups of stimuli confirms that the regularity effect, in this data at least, is confined to words of low frequency.

5.6.2 READING ALOUD

As Table 5.4 below shows, the majority of the participants did score less well on the irregular items.

Table 5.4: Individual Percentage Errors - Regular and Irregular Stimuli (RA)

Participant	Total	% Regular	% Irregular
1	12.7	12.2	13.3
2	9.7	7.5	13.3
3	4.8	4.1	6
4	2.6	1.4	4.8
5	8.7	10.9	4.8
6	5.7	5.4	6
7	34.3	33.3	36
8	7	4.8	10.9
9	3	2	4.8
10	50	51	48.2
11	15.7	15.6	15.7
12	17	16.3	18.1
13	48.7	46.9	51.8
14	32.6	32	33.7

Twelve of the fourteen participants performed less well on irregular stimuli compared to the regular stimuli and the trend of their performance followed similar lines regardless of the actual number of their errors. All twelve showed a percentage of errors on regular words that was lower than their overall error percentage and a percentage of errors on irregular words that was greater than both the overall error percentage and the percentage of errors on regular items. The two exceptions to this were Participants 5 and 10, highlighted in Table 5.4 above. Only a small difference exists in the scores of Participant 10, however Participant 5 shows a considerably poorer performance on regular words when compared to his irregular word performance. A binomial test on the results in Table 5.4 indicated that the probability of so many of the participants performing less well on irregular words was $p<0.006$. This shows that it was not due to chance that so many of the participants found irregular words more difficult to read aloud correctly.

However, although the majority of the participants made more errors on irregular words, there was no significant difference in group performance on regular and irregular words ($t = 1.48$, d.f. = 13, $p<0.16$).

5.6.2.1 The Combined Effects of Regularity and Frequency

A MANOVA investigating the effects of regularity and frequency yielded a highly significant result ($F = 20.15$, d.f. = 3, $p<0.001$). Predictably from the results described above, subsequent t-tests proved that this result was due to the effects of frequency alone. However, the marginally significant result which showed a regular low-irregular low difference ($p<0.06$) does indicate a possible trend in performance on low frequency regular and irregular words, particularly as a stronger result was found on the same categories in VLD

5.6.3 READING FOR MEANING

5.6.3.1 Known Words

Readers knew the meaning of 60% of the regular words and 62% of the irregular words which they read aloud incorrectly. In the case of both regular and irregular words, participants knew the meaning of more of the high frequency items which they had read aloud incorrectly when compared to their knowledge of low frequency words, as is shown in Table 5.5.

Table 5.5: Percentage of Incorrect Words by Regularity and Frequency which were Known (RA)

Frequency	Regular	Irregular
High	74%	71%
Low	54%	57%

5.6.3.2 Unknown Words

No significant effect of regularity was found in participants' performance on words which were unknown to them. Of the regular words which they read aloud incorrectly, participants did not know 40% of them, nor did they know the meaning of 38% of the irregular words. As is shown in Table 6 below, the percentage of incorrectly read unknown words was again very similar for both regular and irregular groups in each frequency band.

Table 5.6: Percentage of Incorrect Words by Regularity and Frequency which were Unknown (RA)

Frequency	Regular	Irregular
High	26%	29%
Low	46%	43%

It seems clear from all the above findings that word regularity did not greatly affect performance on the reading aloud task for these participants. No investigation was made of the combined effects of regularity and frequency with regard to the known or unknown items, as the above findings indicate that any significant effect would be due only to the influence of frequency.

5.6.4 POST-HOC INVESTIGATIONS

A number of post-hoc investigations were carried out on the data to further explore the influence of regularity in reading aloud performance.

5.6.4.1 Re-classification of Stimuli Items

The subjectivity of the regular/irregular distinction was discussed at length in Chapter Three. Based on the classification of other researchers (Coltheart, 1981), four items were re-classified as being irregular rather than regular, these were *sign, doubt, debt* and *psalm*. These particular items would undoubtedly be irregular according to a one-to-one grapheme-phoneme correspondence system, however they would be regular according to a rule-governed system such as that employed by Gonzalez-Rothi et al. (1984). A significant difference in performance on the two word groups was then apparent ($t = 2.62$, d.f. $= 13$, $p<0.021$). The original classification of all the stimuli was well-supported and thus it is argued that this result does not reflect misclassification, but rather serves to emphasize the fragility and subjectivity of this particular classification system.

5.6.4.2 Predictability of Pronunciation

It was considered that a more objective means of classification might be expected to yield a more stable result. Consequently, all the stimuli items were assigned a score based on the Berndt et al. (1987) system of predictability of pronunciation (c.f. 2.9.1 and Appendix One for discussion and full score listings respectively). A one-tailed correlation was performed to see if those words considered highly predictable (i.e. with a predictability score of 1) were less prone to erroneous production than their less predictable counterparts. A significant correlation co-efficient ($r = -.1403$, d.f. = 186, $p<0.028$) was obtained.

5.6.5 SUMMARY OF THE EFFECT OF REGULARITY

The above results have shown not only that the regularity effect in reading aloud appears to be inherently weak when it does occur for participants in this study, but also that the subjectivity of the regularity classification itself makes it difficult to determine the validity of such results. Significant effects found in the following section may be considered to be more reliable due to the more objective nature of the neighbourhood classification system.

5.7 ORTHOGRAPHIC BODY NEIGHBOURS

5.7.1 VISUAL LEXICAL DECISION

There was a significant difference in the correct identification of real words across the different orthographic body types ($F = 2.70$, d.f. = 3, **$p<0.001$**). The only significant pairing, where ***$p<0.005$***, found in follow-up t-tests was the consistent - unique difference ($p<0.004$). The only other differences to approach a significant p-value can be seen in Table 5.7.

Table 5.7: Notable Body Neighbourhood Effects (VLD)

Body Type	P-value
inconsistent - unique	0.006
exception - unique	0.01

In all the cases listed above, unique words were the type which the subject group as a whole found most difficult. The results listed above are in line with both the

Response Time findings (c.f. Chapter Three) and Armstrong's (1993) reading aloud results. This provides an initial indication that the effects of orthographic body neighbourhood may be constant over a variety of tasks. Furthermore, as similar results were found on the Response Time task, this gives some additional support to the notion response times and error scores can validly be equated.

To determine whether the findings with regards to unique words were actually due to body type or were, in fact, solely a frequency effect, the orthographic body neighbourhood data sets were further divided into high and low frequency stimuli. An initially significant result of the Mauchly sphericity test ($w = 0.013$) required that the test be epsilon corrected. The subsequent Huynh-feldt test showed that a significant difference in performance occurred across categories of body and frequency combined ($F = 7.48$, d.f. = 5.97, $p<0.001$). Follow up t-tests (where ***p<0.001***) gave the following significant results.

Table 5.8: Combined Body Neighbourhood and Frequency Effects (VLD)

Body Type	**P-value**
consistent high - unique low	0.0001
exception high - inconsistent low	0.0001
exception high - unique low	0.0001
inconsistent high - unique low	0.001

The results in Table 5.8 indicate that the earlier result, in which unique words appeared to be misidentified as pseudowords more frequently than their consistent, inconsistent and exception word counterparts, was attributable solely to word frequency.

However, the series of results shown in Table 5.9 reached a level very near to significance and these results may suggest that frequency is not an entirely adequate explanation for the greater number of errors made on unique words. They do however indicate that any such effects caused by the orthographic body neighbourhoods themselves are confined to the low frequency members of the groupings (as was the case for regular and irregular words, c.f. Table 5.3).

Table 5.9: Notable Differences in Performance - Body Neighbourhood/Low Frequency (VLD)

Word type	**P-value**
consistent low - unique low	0.004
exception low - unique low	0.006
inconsistent low - unique low	0.008

5.7.2 READING ALOUD

Table 5.10 shows the percentage of errors which participants made on each of the four body neighbourhoods.

Table 5.10: Individual Percentage of Errors: Overall and by Body Neighbourhood (RA)

Participant	Total Incorrect	Consistent Incorrect	Exception Incorrect	Inconsistent Incorrect	Unique Incorrect
1	12.7	12.2	13.8	9.7	15.7
2	9.7	4.1	15.5	9.7	7.8
3	4.8	6.1	1.7	2.7	9.8
4	2.6	0	1.7	1.4	7.8
5	8.7	6.1	3.4	6.9	19.6
6	5.7	2	5.1	1.4	15.7
7	34.3	34.7	32.8	33.3	37.3
8	7	2	6.9	8.3	9.8
9	3	0	5.1	2.7	3.9
10	50	46.9	50	47.2	56.9
11	15.7	2	20.7	18.1	19.6
12	17	6.1	15.5	13.9	33.3
13	48.7	36.7	50	50	56.9
14	32.6	28.6	39.7	25	39.2

As the table above shows, ten of the fourteen participants made more reading aloud errors on unique words than on any of the other neighbourhood body categories. The percentage of errors which they made on this category was considerably greater than the percentages of errors on the other groups, unlike in the regular-irregular classification where only a small percentage more errors were made on irregular than regular words. The four participants (highlighted above) who did not find unique words the most difficult found the exception words the most difficult category to read aloud correctly.

A significant result on a repeated measures ANOVA, ($F = 13.52$, d.f. $= 3$, $p < 0.0001$), indicates that there was also a difference in performance across body types in the reading aloud task. Subsequent t-tests yielded the significant results shown in Table 5.11 (where $p<0.005$).

Table 5.11: Significant Effects of Body Neighbourhood (RA)

Word Type	P-value
consistent - unique	0.001
inconsistent - unique	0.001

Some weaker results which did not reach the level of significance required by Bonferroni's correction were also considered and are shown in Table 5.12.

Table 5.12: Notable Effects of Body Neighbourhood (RA)

Word Type	P-value
exception - unique	0.016
consistent - exception	0.011

The figures shown in Tables 5.11 and 5.12 reflect similar findings to those of the VLD and RT tasks, with the exception of the result highlighted in Table 5.12. To date, no other findings in this study have indicated any difference in performance on consistent and exception words.

5.7.2.1 The Combined Effects of Body Neighbourhood and Frequency

As with the VLD data, the effect of frequency on the results of body types was investigated. The test had to be epsilon corrected due to a significant Mauchly sphericity result (w = 0.01). The subsequent Huynh-feldt test showed a significant difference existed between performance on words depending on their frequency and body type ($F = 14.6$, d.f. = 3.53, $p < 0.0001$). Follow-up t-tests showed that the significant differences lie between the word types shown in Table 5.13 (***p < 0.0017***, Bonferroni corrected).

Table 5.13: Significant Body Neighbourhood and Frequency Effects (RA)

Word Type	P-value
consistent high - exception high	0.001
consistent high - inconsistent low	0.001
consistent high - unique low	0.0001
exception high - unique low	0.0001
inconsistent high - inconsistent low	0.001
inconsistent high - unique low	0.0001
unique high - unique low	0.0001

All of the above results can be explained as being due to an effect of frequency with the notable exception of the first result listed which shows that significantly more high frequency exception words were read aloud incorrectly than consistent words of a similar frequency. The existence of a difference in performance on consistent and exception words was indicated in the results of Table 5.11, but this is the first such significant result to be obtained in this study. It is of particular interest because it occurs between two groups of high frequency words when such significant effects of word type are generally regarded as being confined to those words of low frequency.

Of the many results which were marginally significant in the same analysis, a further three could not be accounted for by frequency effects.

Table 5.14: Notable Body Neighbourhood and Frequency Effects (RA)

Word Type	**P-value**
consistent low - unique low	0.002
consistent high - unique high	0.007
inconsistent high - exception high	0.003

These results suggest that the weakness of unique words in comparison with performance on both their high and low frequency consistent counterparts cannot be explained purely in terms of a frequency effect. The relationship between unique and inconsistent words, on the other hand, can apparently be accounted for by frequency alone. This fact makes the final result in Table 5.14 particularly interesting. The indication is that the exception effect highlighted in Table 5.13, between high frequency consistent and exception words, also exists (albeit to a lesser extent) between inconsistent and exception words. Such an effect would appear to be generally masked by poorer overall performance on low frequency words.

Given the above results, further investigation of the actual frequency of the stimuli seemed prudent. If the mean frequency of the word types were to differ significantly within each frequency band, then that would provide an explanation for the above effects. A one-way ANOVA showed a significant difference in frequency across the groups of low frequency words ($F = 5.72$, d.f. $= 3$, $p < 0.0012$). A post hoc Scheffé test showed that low frequency consistent words had a significantly higher frequency than either low frequency inconsistent or unique words. This would appear to explain why performance on low frequency consistent words was considerably better than that on their unique word peers. The absence of such an effect between low frequency consistent and inconsistent words, given that like unique words inconsistent words also have a lower mean frequency, further supports the suggestion that whilst the effect of frequency may be largely responsible for poor unique word performance, it is not solely so.

A similar comparison across high frequency words showed no such significant difference in the mean frequencies of the different body types. This investigation therefore failed to yield a satisfactory explanation for the high frequency exception effects shown in Tables 5.13 and 5.14 and also for the high frequency unique effect identified in Table 5.14. An investigation of participants' apparent knowledge of the words which they read aloud incorrectly may provide an explanation.

5.7.3 READING FOR MEANING

5.7.3.1 Known Words

The significant difference in performance across body type was maintained over the words which participants read aloud incorrectly in spite of appearing to know their meaning ($F=3.84$, d.f.=3, $p < 0.017$). Subsequent t-tests did not show any significant difference in performance between specific groups ($\boldsymbol{p < 0.008}$, Bonferroni corrected) and only two differences reached near significance.

Table 5.15: Notable Body Neighbourhood Effects for Known Words (RA)

Word Type	P-value
consistent - unique	0.011
inconsistent - unique	0.023

Although considerably weaker, the effects shown in Table 5.15 are similar to those found in the data-set as a whole (c.f. Table 5.8) and it would seem likely, based on previous results, that such findings are likely to be explicable largely by the effect of frequency.

A MANOVA on body and frequency showed a much greater significant difference in reading aloud performance on familiar words ($F = 5.33$, d.f. $= 7$, $p < 0.0001$). Table 17 shows the significant results that were isolated by subsequent t-tests (***p < 0.0017***, Bonferroni corrected):

Table 5.16: Combined Effects of Body Neighbourhood and Frequency on Known Words (RA)

Word Type	P-value
consistent high - inconsistent low	0.001
inconsistent high - inconsistent low	0.001

Both of the above results are due simply to differences in frequency, however they fail to explain the unique word effects shown in Table 5.17. Examination of those results which were of marginal significance displayed a similar trend to earlier results (c.f. Tables 5.13 and 5.14).

Table 5.17: Body Neighbourhood Effects: Known Words (RA)

Word Type	P-value
consistent high - exception high	0.026
consistent high - unique high	0.012
inconsistent high - exception high	0.035
inconsistent high - unique high	0.04

A high frequency unique effect occurs and may be said to be supported by the significant difference in performance on high frequency inconsistent and unique words. The existence of a high frequency exception effect in this case suggests that it is not lack of familiarity with high frequency exception words that has led to their poor performance results.

As Table 5.18 shows, readers appeared to know the meaning of a similar percentage of the incorrectly read words from each neighbourhood group, within a given band of frequency.

Table 5.18: Percentage of Incorrectly Read Words by Body Neighbourhood and Frequency which were Known (RA)

Frequency	Consistent	Exception	Inconsistent	Unique
High	74%	73%	67%	76%
Low	55%	55%	59%	51%

5.7.3.2 Unknown Words

A significant difference in performance on words which appeared to be unknown to the readers was found across the body types ($F = 9.42$, d.f. $= 3$, $p < 0.0001$). The following significant results were obtained from matched pairs t-tests (*p < 0.008*, Bonferroni corrected).

Table 5.19: Effects for Unknown Words (RA)

Word Type	Unknown Words
consistent- unique	0.001
inconsistent - unique	0.002

Although it should be noted that the numbers were very small, a significant effect was also found to be present in the combined body and frequency of unknown words (F = 7.73, d.f. = 1.88, p< 0.0001). None of the subsequent t-tests yielded a significant result when Bonferroni's correction was applied (*p<0.001*), however the following two groups showed a marginal significance, a difference which could not be accounted for by frequency.

Table 5.20: Notable Body Neighbourhood and Frequency Effects: Unknown Words (RA)

Word Type	P-Value
consistent low - unique low	0.004
inconsistent low – unique low	0.007

It would appear that the previous effects of low frequency unique words were indeed not only due to frequency, as might have been assumed when the significant difference in mean frequencies was discovered, but also to the fact that subjects were unfamiliar with the unique words. Perhaps, having no support from other similarly spelled words, as none exist, they found it more difficult to derive a correct pronunciation for the stimuli.

Of the words which were read aloud incorrectly there was an even spread of words which were unknown to the readers across the four neighbourhoods within each frequency band.

Table 5.21: Percentage of Incorrect Words by Body Neighbourhood and Frequency which were Unknown (RA)

Frequency	Consistent	Exception	Inconsistent	Unique
High	26%	27%	33%	24%
Low	45%	45%	41%	49%

A slightly higher percentage of low frequency unique words were unknown to the participants and this supports the above explanation as to why a low frequency unique effect was found. However, the fact that readers knew a slightly greater percentage of the high frequency unique words than the words of other neighbourhoods fails to explain why such a unique effect, albeit a relatively weak one (c.f. Table 5.17) should exist amongst the high frequency word groups.

It appears that the high frequency exception effects cannot be explained by any of these results. It can therefore be assumed that it is neither differences in mean frequency nor lack of lexical knowledge of these stimuli that is responsible for the relatively poor performance on high frequency exception words. Some other factor must therefore be responsible.

5.7.4 POST-HOC INVESTIGATIONS

As with the regularity data, a number of post-hoc investigations were performed on the body neighbourhood data.

5.7.4.1 Comparison with Armstrong (1993)

Table 5.22 shows the percentage of errors made on each body type alongside Armstrong's (1993) data on similar groups of words.

Table 5.22: Present Percentage Errors Made Across Body Neighbourhoods (RA) Compared with Armstrong's Data (1993)

Body Type	% Errors	Armstrong's Data
consistent	13.4	13.5
exception	18.7	7.9
inconsistent	16.5	13
unique	23.8	21.7

The comparisons with Armstrong's data are interesting. Performance on consistent and unique words appears to be equal across the two groups, but an anomaly occurs in the performance on exception words. Armstrong's group not only performed more than twice as well as the group in the current study, but also performed better on exception words than on any of the other categories.

5.7.4.2 Gang Words

Although not subjective in the sense of the regular/irregular classification there are many possible sub-divisions in the classification of orthographic body neighbours.

As was discussed in Chapter Two, inconsistent words can be further sub-divided to allow for those words which have both friends and a number of different enemy rimes, e.g. *tomb* which has a friend in *womb* and enemies in both *bomb* and *comb*, to be considered as a separate group from those words which possess only one enemy rime, e.g. *mint*, and all the words rhyming with it, which disagrees in pronunciation only with the word *pint*. It is possible that the generality of the inconsistent category could exaggerate the word effects already examined, so such a classification was invoked on the original word groupings leading to the creation of a fifth group, *gang* words.

Table 5.23: Significant Body Neighbourhood Effects: With G*ang* Words (RA)

Word Type	Gang Result
consistent high - exception high	0.006
consistent high - unique high	0.005
inconsistent high - unique high	0.002
inconsistent low - unique low	0.04

The results indicate that some difference occurs between performance on inconsistent and unique words of both high and low frequency. This is a particularly unexpected result in the case of the low frequency words as inconsistent and unique low frequency words have been shown to have a similar mean frequency yet it is a difference in mean frequency that has, so far, largely been used to explain the difference in performance on low frequency consistent and unique words. This does draw into question the intrinsic value of classification by body neighbourhood, as it suggests that the results may depend on the choice of categories, in much the same way as they are affected according to the chosen definition of regularity. The exception effect in the presence of high frequency consistent words occurs in both methods of classification. This indicates that it is unaffected by alterations to body neighbourhood classification. Its continued presence might be argued to strengthen the importance of this effect.

5.7.4.3 Neighbourhood Categorisations after Brown (1987)

Brown (1987) argued that unique and exception words were functionally identical as they were both examples of words which were the only item to possess a particular pronunciation for their particular orthography. A repeated MANOVA of the three categories, consistent, inconsistent and (exception + unique), produced a, predictably, significant result ($F = 14.09$, d.f. = 2, $p<0.0001$). Paired samples t-tests gave the following significant results.

Table 5.24: Significant Body Neighbourhood Effects: Exception and Unique Words Combined (RA)

Word Type	**P-value**
consistent - (exception + unique)	0.0001
inconsistent - (exception + unique)	0.001

These results are hardly surprising given the fact that in isolation unique and exception words are read less successfully than consistent and inconsistent words.

5.7.4.4 Omitting Unique Words

Few current studies have included the unique word category. Omitting the unique data entirely from the investigation, a significant difference still existed across body types (F = 5.96, d.f. = 2, $p<0.007$) with subsequent t-tests showing that the responsibility for the significance lay between consistent and exception words ($p<0.01$). Inclusion of frequency in the analysis also yielded a significant result (F = 8.20, d.f. = 3.49, $p<0.0001$) and of the significant results obtained in subsequent t-tests those shown in Table 5.25 could not be explained purely by frequency. This, yet again, reinforces the results previously described and further emphasises the strength of the high frequency exception effect.

Table 5.25: Significant Differences when Excluding Unique Words (RA)

Word Type	P-value
consistent high - exception high	0.001
inconsistent high - exception high	0.003

5.7.4.5 High Frequency Exception Word Stimuli

Given the repeated finding of a high frequency exception effect, further investigations were made regarding the actual stimuli themselves. Of the 36 high frequency exception stimuli, errors were made on 28 (77.7%) of them, so the results could not be accounted for by mistakes on only one or two specific items. Likewise, all the participants, apart from Participant 9, made errors on this stimuli group, so the findings were not due to the difficulties of only certain participants in the study. Based on the findings of earlier studies, two further investigations were carried out in an attempt to account for the high frequency exception word findings. A study by

Coltheart and Rastle (1994) suggested that the nearer to the start of a word the exceptionally pronounced phoneme was, the greater the chance of an error occurring in pronouncing that item. The high frequency exception stimuli were classed according to the position of their exception phoneme. Of the 65 errors made on this category, 55 were made on words that were exceptional at the second phoneme, compared to only 4 errors made on words exceptional at the first phoneme. However, only 6 errors were made on the words exceptional at the third phoneme and of the 9 items which were read aloud correctly by all the participants, 7 were exceptional at the second phoneme and 2 at the third. Thus, the results proved inconclusive as nearly all the words were exceptional at the second phoneme and errors occurred on nearly all the stimuli items anyway.

An investigation into the effect of cumulative frequency proved more fruitful. Jared (1997) found that latency times on high frequency inconsistent words were longer than on their consistent word counterparts and identified the cause as being the high cumulative frequency of the body neighbourhood enemies of the inconsistent words compared to the cumulative frequency of their friends. The same principle was applied in this study to the exception word items. The high frequency exception words were found to have a high cumulative frequency of enemies (9189) which might explain their considerable weakness in comparison to the consistent word items which had only friends. Their performance in comparison to high frequency inconsistent words was less easy to explain as it was found that the enemies of the inconsistent items had an even higher cumulative frequency (24892). However, it was also calculated that the inconsistent words had a still higher cumulative frequency of friends (26178), and if the effect of friends is held to be stronger than the effect of enemies then this may account for the better performance on inconsistent words than on exception words.

5.7.4.6 Unique Word Stimuli

Although the findings with regard to unique words could be largely accounted for in terms of low mean frequency and lack of familiarity in the case of the low frequency unique stimuli, the results indicated that these alone were not sufficient to explain the errors on these words. Nor could the errors on high frequency unique words be explained in this manner. Consequently, further investigations were carried out similar to those which were made in relation to high frequency exception words (see above). All the participants made some errors on low frequency unique words and errors were made on all the items. In the case of high frequency unique words, only Participants 3 and 6 made no errors and errors were made on 20 of the 26 items (76.9%). Once again, the errors could not be accounted for either by a few rogue items or by the performance of a specific participant(s).

5.7.5 SUMMARY OF BODY NEIGHBOURHOOD EFFECTS

A number of body neighbourhood effects were identified. Unique words, particularly those of low frequency were found to be especially vulnerable to reading aloud errors. Post-hoc investigations indicated that this finding was largely due to the particularly low mean frequency of these items when compared to the mean frequency of the other body neighbourhood items. High frequency exception words were the other group which proved to be difficult for participants to read aloud correctly. The frequency of these items was not found to be responsible for this finding. Rather it appeared that such a finding is best explained by a frequency effect of body neighbourhood friends and enemies, where high frequency exception words suffer particularly because they have no body friends and high frequency body enemies.

5.8 PSEUDOWORD RESULTS

5.8.1 VISUAL LEXICAL DECISION

By their very nature, pseudowords cannot be classed according to frequency or regularity, consequently the only analysis to be performed on this data set was an ANOVA to investigate the effect of orthographic body type on correct identification. No significant difference was found to exist in this case on performance of the different body types. Pseudowords of all body endings appear to be equally likely to be incorrectly classified as real words. This finding perhaps further emphasizes the strength of the role played by frequency in the real word results, i.e. an effect may only occur in items where frequency is a relevant factor.

5.8.2 READING ALOUD

Participants 1-10 and 13 performed reading aloud for pseudowords and pseudohomophones (although Participant 6 did not attempt pseudohomophones). A significant effect for body type was found ($F = 7.13$, d.f. $= 2$, $p<0.005$) and subsequent t-tests showed that performance was found to vary significantly on two categories, as shown in Table 5.26.

Table 5.26: Significant Differences by Body Neighbourhood: Pseudowords (RA)

Word Type	P-value
consistent - unique	0.04
inconsistent - unique	0.01

These results show the same trend as that of the real word errors, namely poorer performance on unique type stimuli. In this case, the difference in performance on inconsistent and unique items appears to have been greater than that on consistent and unique items.

5.8.2.1 Near-to-Correct Pronunciations

Further support for the recognition of orthographic body as a functional unit is provided by investigation of a subgroup of the pseudowords on which errors were made. Pseudoword errors were categorised as being either "near" or "far" from the target in terms of their pronunciation (examples). On the "near" category, there was a significant effect of body type ($f= 7.24$, d.f. $= 2$, $p < 0.004$) for which again similar differences were responsible:

Table 5.27: Significant Differences in Performance by Body Neighbourhood (RA): Pseudowords with a Near-to-Correct Pronunciation

Word Type	P-value
consistent - unique	0.018
inconsistent -unique	0.011

Again, the difference in inconsistent - unique reading aloud performance was greater than that of consistent - unique performance, a particularly surprising finding as the conflicting pronunciations in the inconsistent group might be expected to cause more rather than less difficulty.

5.8.2.2 Correctly Read Pseudowords

When analysing the word data there was no new information to be gained by considering the words that subjects read aloud correctly, as that outcome could have been due simply to knowledge of the specific item and not related to its regularity or orthographic neighbourhood. However, in the case of pseudowords, the ones which subjects read aloud correctly are of as much interest as the ones they did not. Predictably, given the results of the analysis of incorrectly read pseudowords, a significant effect of body type was found ($F = 11.83$, d.f. = 2, $p<0.001$). The breakdown of results was equally predictable, with performance on unique based items being considerably less good than that on the other two groups.

Table 5.28: Significant Body Neighbourhood Effects for Correctly Read Pseudowords (RA)

Word Type	P-value
consistent - unique	0.005
inconsistent - unique	0.005

5.8.2.3 Pseudowords Given a Body-Based Pronunciation

Of those 677 pseudowords (out of the 1793 pseudoword items attempted) which were read correctly, 89% were given a predictable, i.e. body-based, pronunciation, the remaining 11% were pronounced correctly but with an unpredictable pronunciation. Analysis of the predictable pronunciations showed a significant effect of word body ($F = 11.30$, d.f. = 2, $p<0.001$). The results of subsequent t-tests are shown in Table 5.29 below.

Table 5.29: Significant Differences by Body Neighbourhoods (RA): Correctly Read Pseudowords (body-based pronunciation)

Word Type	P-value
consistent - unique	0.007
inconsistent - unique	0.006

No such significant effect was found for unpredictably pronounced pseudowords.

5.8.2.4 Unique Word Stimuli

Further investigation was made of the actual unique word stimuli to see if any particular items or participants were responsible for the significant findings regarding this category of stimuli. All the participants who performed pseudoword reading aloud made some mistakes on the unique-type pseudowords and mistakes were made on all 48 items.

Unique-type pseudowords differ from all the other pseudowords in that their creation is based solely on one real word item. Consequently, it is possible to divide such stimuli into two groups based on the frequency of the real word item from which they were derived. This is not possible for the other groups of pseudowords as they may have real word body neighbours of both high and low frequency. It was predicted that more errors would be made on the pseudoword stimuli that were based on low frequency unique words than on those which were based on high frequency unique words. Of the 48 items, 24 were based on high frequency unique words and 24 on low frequency unique words. It was found that participants made 177 errors on the low frequency type items and 187 on the high frequency ones. Not only was this result in direct conflict with the expected findings of this investigation, but it might also be thought to add weight to the argument that frequency alone cannot be held to account for errors on low frequency items, for if this were the case then surely the findings here would have been the reverse.

5.9 PSEUDOHOMOPHONE RESULTS

5.9.1 VISUAL LEXICAL DECISION

As in the case of the pseudowords, only performance by body type could be analysed. An ANOVA result which bordered on significant ($F = 3.22$, d.f. = 2, $p<0.057$) suggested that further analysis might be appropriate. However, the only comparison reaching marginal significance (where $\boldsymbol{p<0.005}$) is the unique-inconsistent pairing ($p<0.008$), with the inconsistent-type stimuli being more frequently mistaken for real words than the unique-type stimuli. This finding may indicate that inconsistent non-word items are considerably more "word-like" than other non-word items and hence are more likely to be mistaken for real words. The results of the pseudohomophone items in the RA task may provide clarification of these findings.

5.9.2 READING ALOUD

Those pseudohomophones which were read aloud incorrectly showed a significant effect of body type ($f = 7.91$, D.F. = 2, $P<0.004$). Table 5.30 shows the groups between which significant differences of performance occurred.

Table 5.30: Significant Body Neighbourhood Effects: Incorrectly Read Pseudohomophones (RA)

Word Type	P-value
consistent - unique	0.023
inconsistent - unique	0.009

Unique-type pseudohomophones fared less well than consistent or inconsistent ones.

5.9.2.1 Correctly Read Pseudohomophones

Effects for those items which were read aloud correctly are shown in Table 5.31 below.

Table 5.31: Significant Body Neighbourhood Effects: Correctly Read Pseudohomophones (RA)

Word Type	Pseudohomophone Result
consistent - unique	0.007
inconsistent - unique	0.002

Performance on consistent and inconsistent type pseudohomophones was significantly better than that on unique type items. The trend of performance is particularly interesting when considered in the light of the pseudohomophone VLD findings which indicated that inconsistent type pseudohomophones were more likely to be mistaken for real words than the other groups of pseudohomophone stimuli.

5.10 TASK SUMMARIES

5.10.1 PERFORMANCE ACROSS STIMULI TYPES ON VLD

Table 5.32 shows the percentage of errors which each participant made on the three types of stimuli in the VLD task.

Table 5.32: Individual Performance across Stimuli Types on VLD

Participant	Word % Incorrect	Pseudoword % Incorrect	Pseudohomophone % Incorrect
1	30.8	6.1	12.5
2	3.8	0	8.3
3	13.5	15.2	8.3
4	9.6	3	4.2
5	11.5	3	20.8
6	3.8	18.2	20.8
7	34.6	12.1	20.8
8	15.3	30.3	25
9	3.8	3	12.5
10	25	27.3	12.5
11	21.2	3	8.3
12	15.4	15.2	8.3
13	28.8	18.2	29.1
14	28.8	6.1	12.5

The results were very variable, ranging from 3.8-34.6% of errors on words, 0-30.3% on pseudowords and 4.2-29.1% on pseudohomophones.

Overall, more errors were made on real words than on either of the other two stimuli types, i.e. more words were mistaken for non-word letter strings than vice versa. Performance on pseudowords was better than that on either of the other two stimuli types.

Table 5.33: Comparison of Performance across Stimuli Types on VLD

Stimuli Type	**Total Tested**	**Incorrect**	**% Incorrect**
Word	728	128	17.6
Pseudoword	462	53	11.5
Pseudohomophone	336	49	14.6

Of the real word items, frequency was the most significant factor in determining successful performance. Words which were both low in frequency and irregular proved most difficult for people with dyslexia to identify. A series of weaker results implied that unique words of low frequency may also prove more difficult for people with dyslexia than words of other body types. No clear findings resulted from either branch of the non-word data with regard to body types.

5.10.2 PERFORMANCE ACROSS STIMULI TYPES ON RA

Table 5.34 shows the percentage of errors which individual participants made on the different stimuli types in the RA task.

Table 5.34: Individual Performance across Stimuli Types in RA

Participant	Word % Incorrect	Pseudoword % Incorrect	Pseudohomophone % Incorrect
1	12.7	43.6	61.9
2	9.7	76.7	61.9
3	4.8	52.2	39.2
4	2.6	44.2	27.8
5	8.7	44.2	49.5
6	5.7	51.5	-
7	34.3	98.2	80.4
8	7	55.2	47.4
9	3	24.5	10.3
10	50	94.5	89.7
11	15.7	-	-
12	17	-	-
13	48.7	100	100
14	32.6	-	-

As in the VLD task, there was a range of results, 2.6-50% for words, 24.5-100% for pseudowords and 10.3-100% for pseudohomophones. Performance across the three stimuli groups was fairly constant in most participants, the participant who made the greatest number of errors on the word stimuli also made the most errors on the other two types.

Reading Aloud performance on real words was considerably better than on pseudowords or pseudohomophones. The percentage of errors made on pseudowords was considerably bigger than that on pseudohomophones, as is shown in Table 5.35 below.

Table 5.35: Comparison of Performance Across Stimuli Types in RA

Stimuli Type	Total Tested	Incorrect	% Incorrect
Word	3220	580	18
Pseudoword	1793	1116	62.2
Pseudohomophone	970	551	56.8

In reading aloud, unique words suffered more than both high and low frequency consistent and inconsistent words, although the low frequency effect was found to be largely due to a difference in the mean frequency between the categories. The most interesting finding was the relatively poor performance on high frequency exception words compared to that on high frequency consistent and inconsistent words. The differences in performance on high frequency words were not due to an imbalance in mean frequency across the different body neighbourhood groups. Reading aloud of both pseudowords and pseudohomophones showed a similar effect of performance on unique-type stimuli.

5.10.3 OVERVIEW OF PERFORMANCE ON VLD AND RA TASKS

As the results in Table 5.36 show, almost four times as many errors were made on pseudohomophones and over five times as many on pseudowords in the RA task than in the VLD task. Performance on words was constant across the two tasks.

Table 5.36: Performance on Stimuli Types on VLD and RA

Stimuli Type	VLD % Incorrect	RA % Incorrect
Word	17.6	18
Pseudoword	11.5	62.2
Pseudohomophone	14.6	56.8

The performance of individual participants on the VLD and RA tasks is shown in Table 5.37 below. The majority of the participants made considerably more errors on the Visual Lexical Decision task than they did on the Reading Aloud task.

Table 5.37: Individual Performance on VLD and RA

Participant	VLD % Incorrect	RA % Incorrect
1	30.8	12.7
2	3.8	9.7
3	13.5	4.8
4	9.6	2.6
5	11.5	8.7
6	3.8	5.7
7	34.6	34.3
8	15.3	7
9	3.8	3
10	25	50
11	21.2	15.7
12	15.4	17
13	28.8	48.7
14	28.8	32.6

The frequency effect occurred in both tasks. Both recognition and pronunciation of low frequency words was less good than that on high frequency words. Regularity shows an effect in VLD ($p<0.007$) and low frequency words are generally responsible for that effect ($p<0.002$). No such significant difference was found in reading aloud performance. Conversely, body effects are more apparent in reading aloud than in lexical decision. In VLD, unique words fared less well than all other categories and again the effect was confined to low frequency words, whereas in RA unique words of both frequency groups were more often incorrectly pronounced than words of other neighbourhoods. A high frequency effect was found for exception words in the RA task, no evidence was found of a similar effect in the VLD task.

5.10.4 RFM TASK SUMMARY

Of all the words which were read incorrectly, 39% of those tested in RFM proved to be unknown to the readers. These were therefore assumed to be words which would have had no semantic back-up to assist their pronunciation. The other 61% were known to the readers, so it can be assumed that it was not lack of semantic knowledge which impeded their correct production.

The unique word effects were found, in the case of low frequency words at least, to be partly explicable in terms of lack of lexical knowledge on the part of the subjects. No such finding was made with regard to the high frequency exception effect. Similar percentages of words from each category were known to the participants but incorrectly pronounced in the case of all the paradigms - frequency, regularity and orthographic body neighbourhood.

5.11 QUALITATIVE STUDY OF ERRORS

As well as investigating the number of RA errors made by the participants, the number of errors of each type that were made was also recorded.

5.11.1 INTER-RATER RELIABILITY

The errors which participants made on the RA task were phonetically transcribed and categorised according to the eventual definitions which are stated in Chapter Four (4.3.5). It was recognised that some errors could be classed as either visual or phonological so it was decided that errors should be categorised in a hierarchical manner. Hence, if an error fitted the visual categorisation it was classed as such regardless of its phonological similarity to the target. It is recognised that this may lead to the visual category being over-subscribed, but it does ensure that the approach to classification in this study could be uniformly applied to any replication studies. The errors were categorised by an independent assessor and the two sets of categorisations were then compared. There was an 84% agreement in initial categorisations and there was no disagreement at all on the visual and phonological categorisation using the criterion discussed above. Detailed examination showed that all the discrepancies involved errors which had been classed as phonological by one rater and neologisms by the other. Further discussion between the two raters was required for clarification of the differences between the two. It was determined that the definition proposed by Ryalls et al. (1988) should be adopted (c.f. 4.3.5.6). Using this more exacting definition, the items in question were successfully re-classified with complete agreement by both raters.

This issue emphasises the importance of clear definitions being provided for any study investigating error types. It is particularly important that such definitions are clearly stated so that future studies aiming to replicate the results have adequate definitions to inform their own attempts at categorisation. A complete list of the actual errors which were made and their classifications can be found in Appendix Four.

5.11.2 REAL WORD ERRORS

Table 5.38 shows the spread of errors, both as raw numbers and as a percentage of the total errors made. Error types are listed in rank order according to the percentage of the total errors for which they account.

Table 5.38: Error Types (RA)

Error Type	Total Errors	% of Total Errors
Visual	189	32.6
Neologism	78	13.5
Phonological	75	12.9
Perseveration	70	12.1
Derivational	53	9.1
Initial Letter	46	7.9
MDE	42	7.2
Unrelated	12	2.1
Semantic	7	1.2
Letter-by-letter	5	0.9
No Response	3	0.5
Total Errors	580	

Visual errors were the most common type of error. The raters' initial dispute over classification indicated the similarity between neologisms and phonological errors, a link supported by the error type literature discussed in Chapter Four. However, even if the phonological and neologistic errors were to be considered as one type of error they would only have accounted for 26.4% of the total errors made and would still be outranked by the number of visual errors. Four types of errors (semantic, letter-by-letter, unrelated errors and no responses) accounted for a combined total of only 4.7% of the errors made. Although listings will be given for these errors in most of the following tables of results, they will not be the focus of any discussion as the numbers involved are too small to support any conclusions.

5.11.2.1 INDIVIDUAL PARTICIPANT ERRORS

The number of errors of each of the error types made by individual participants is shown in Table 5.39 below. The numbers of semantic, unrelated, letter-by-letter errors and no responses were so small that they have been grouped together and are listed in the column headed "other". Overall, the greater the number of errors a participant made, the greater the spread of error type.

Table 5.39: Participant Error Scores by Error Type

Participant	Visual	Neologism	Phonological	Perseveration	Derivational	Initial letter	MDE	Other	Total errors by participant
1	9	7	8	-	-	2	3	-	29
2	5	2	2	-	8	2	2	1	22
3	4	3	4	-	-	-	-	-	11
4	1	-	2	-	1	2	-	-	6
5	8	2	3	1	2	-	3	1	20
6	7	1	2	-	2	1	-	-	13
7	19	10	10	15	12	7	4	2	79
8	7	3	6	-	-	-	-	-	16
9	2	-	2	-	-	1	1	1	7
10	34	35	19	5	5	7	6	4	115
11	13	2	5	7	3	1	3	2	36
12	11	3	4	4	7	2	3	5	39
13	35	5	3	38	6	9	10	5	112
14	34	5	5	1	7	12	7	4	75
total	189	78	75	70	53	46	42	27	580

The majority of the participants made more visual errors than errors of any other type. The only particularly notable feature of the error patterns of the participants is the fact that two of the participants (who both made many RA errors in general) were responsible for 53 of the 70 perseverative errors. It is not the case for any other error type that such a minority of participants made most of the errors.

Although the number of errors each participant made of each error type appears to be vastly different in some cases, e.g. Participant 9 made 2 visual errors and Participant 10 made 34, when those errors are viewed as a percentage of the total errors a participant made the scores are much more consistent. This is illustrated in Table 5.40 below which compares the actual number of visual errors each participant made with the percentage of their total errors which were accounted for by visual errors.

Table 5.40: Participant Errors: Visual Errors

Participant	No. of Errors	Percentage Errors
1	9	31.3
2	5	22.7
3	4	36.4
4	1	16.7
5	8	40
6	7	53.8
7	19	24.1
8	7	43.8
9	2	28.6
10	34	29.3
11	13	36
12	11	28.2
13	35	31.3
14	34	45.3

5.11.2.2 Error Type and Word Type

The Error Type and Word Type Hypothesis in Chapter Four stated that error type would be linked to word type. Chi-squared tests were carried out to investigate whether there was in fact any relationship between the type of error and frequency, regularity or body type. Semantic, letter-by-letter, unrelated errors and no responses were omitted from the analysis as there were insufficient numbers of them to include.

No significant difference occurred between error type and any of the word types or classifications so the hypothesis was not supported. However, although no significant difference was found, the following tables show that some links can be identified.

The uneven numbers of stimuli in the sub-groups of each classification, e.g. participants were tested on 128 high and 102 low frequency words, means that a direct comparison of the numbers of errors made on each group would be misleading. A greater number of errors on high frequency words would not necessarily indicate that high frequency words are more susceptible to such errors than their low frequency counterparts - the number of errors may simply be inflated by the larger number of stimuli initially tested. In order to ensure that the results described are meaningful, each type of error will be considered only in terms of the number of total errors that were made within a given sub-group. For example, in Table 5.41 below each error is shown as the percentage of errors for which it was responsible within one frequency band, so that for example of all the errors made on high frequency words 40.7% were visual in nature. The total number of errors made on a particular sub-group is listed at the top of the relevant column so that the actual numbers of errors involved are clear to the reader.

Table 5.41: Error Type and Frequency

Error Type	Frequency	
	High	Low
Total Errors	204	306
Visual	40.7	28.2
Neologisms	11.8	26.5
Phonological	9.3	14.9
Perseveration	7.8	14.4
Derivational	8.3	9.6
Initial Letter	8.8	7.4
MDE	9.3	6.1
Unrelated	2	2.1
Semantic	0.5	1.6
Letter-by-letter	1.5	0.5
No Response	0	0.8

A considerably greater percentage of the errors made on high frequency words were visual when compared to the percentage of such errors made on the low frequency items. The reverse was true of neologisms, phonological and perseverative errors which accounted for 28.9% of the total errors on high frequency words, but 55.8% of the total errors on low frequency words. The percentage of such errors on low frequency words was considerably higher than the percentage of such errors on the stimuli items as a whole group (Table 5.38). Similar percentages of derivational and initial errors occurred on both groups whereas slightly fewer of the more complex MDE errors were made on low frequency words.

5.11.2.3 Error Type and Regularity

Table 5.42 shows the percentage of each error type made on regular and irregular words. Very slight variations occur across some of the groups, but none of these amount to more than a 3% difference. The percentage of each error type on both groups are also very similar to the percentages of each error type on the whole data set. So, as was the case with the quantitative study of errors, the classification of regularity did not explain the findings.

Table 5.42: Error Type and Regularity

Errors	Regular	Irregular
Total Errors	358	222
Visual	31.4	34.6
Neologisms	14.2	12.1
Phonological	13.1	12.6
Perseveration	11.2	13.5
Derivational	9.2	8.9
Initial Letter	7.9	7.9
MDE	7.9	6.1
Unrelated	1.9	2.3
Semantic	0.2	0.9
Letter-by-letter	0.8	0.9
No Response	0.8	0

Only 15 out of the total 580 errors were identified as LARC errors. Six of these were made on regular words and nine were made on irregular words and could therefore be called *regularisations*. Participants knew all but two of the irregular words on which the mistakes were made.

5.11.2.4 Error Type and Body Neighbourhood

Of all the visual errors, 40% were made on words where the target and production shared a body, i.e. the error occurred on the onset. Of these, 19% shared the same body pronunciation as the target e.g. *dive→drive*, whilst 21% did not e.g. *bead→bread*. For nearly half of these items (43%) the RFM task indicated that the target word was unknown to the participant.

The spread of error types across the different body neighbourhoods, as listed in Table 5.43, is considerably less even that that across regular and irregular words. Considerably higher percentages of visual errors were made on exception and inconsistent words, whereas high percentages of neologisms, phonological and perseverative errors were made on unique words. Consistent words showed particularly high percentages of phonological and initial letter errors. Complex MDE errors accounted for a higher percentage of inconsistent word errors than MDE errors on any of the other body types.

Table 5.43: Error Type and Body Neighbourhood

Error Type	Body Neighbourhood			
	Consistent	**Exception**	**Inconsistent**	**Unique**
Total Errors	92	152	166	170
Visual	27.2	36.8	40.4	24.1
Neologism	12	13.8	9	18.2
Phonological	18.5	10.5	10.8	14.1
Perseveration	12	11.2	9.6	15.3
Derivational	10.9	11.2	8.4	7.1
Initial Letter	10.9	7.9	7.2	7.1
MDE	5.4	5.9	10.2	6.5
Unrelated	2.2	1.3	1.8	2.9
Semantic	1.1	0	1.2	2.4
Letter-by-letter	0	1.3	0	1.8
No Response	0	0	1.2	0.6

The results reported in earlier sections of this chapter indicated that unique words and high frequency exception words were particularly vulnerable to reading aloud error. The error types made on these word categories were investigated to determine if any relationship was apparent between error types and these particular body neighbourhoods.

Table 5.44: Unique Word Errors by Type and Frequency

Error Type	Frequency	
	High	**Low**
Total Errors	51	119
Visual	31.4	21
Neologism	13.7	20.2
Phonological	15.7	13.4
Perseveration	7.8	18.5
Derivational	5.9	7.6
Initial Letter	7.8	6.7
MDE	9.8	5
Unrelated	2	3.4
Semantic	2	2.5
Letter-by-letter	3.9	0.8
No Response	0	0.8

A relatively low percentage of the errors on low frequency unique words were visual errors, whereas higher percentages of neologisms and perseverative errors were made.

Table 5.45: Exception Word Errors by Type and Frequency

Error Type	Frequency	
	High	**Low**
Total Errors	74	78
Visual	39.2	21.8
Neologisms	12.2	9.7
Phonological	9.5	7.3
Perseveration	8.1	8.9
Derivational	9.5	8.1
Initial Letter	8.1	4.8
MDE	9.5	1.6
Unrelated	2.7	0
Semantic	0	0
Letter-by-letter	1.4	0.8
No Response	0	0

Again, there was a lower percentage of visual errors on low frequency words. There was a slightly higher percentage of visual errors on high frequency exception words that on the stimuli group as a whole. The error type percentages on high frequency exception words were very similar to the spread of percentage errors on high frequency words in general.

5.11.2.5 Error Type and Word Knowledge

In Table 5.46, the distribution of errors over known and unknown words is compared alongside those results already shown in Table 5.41.

Table 5.46: Error Type and Word Knowledge

Error Type	All Words	Known Words	Unknown
Visual	32.6	34.2	30.7
Neologisms	13.5	15	8.9
Phonological	12.9	15.3	9.4
Perseveration	12.1	6.4	21.8
Derivational	9.1	12.1	4.5
MDE	7.2	5.8	8.4
Initial Letter	7.9	6.7	10.9
Unrelated	2.1	1.3	3.5
Semantic	1.2	1.9	0.5
Letter-by-letter	0.9	0.9	0.5
No Response	0.5	0.3	0.9

Based on the results shown in Table 5.46, it appears that knowledge of a word's meaning does not affect the occurrence of visual errors, as similar percentages of visual errors were made on both the known and unknown stimuli. However, a greater percentage of the errors on words which were known to the participants were derivational errors. Indeed, the percentage of such errors on known words was nearly three times greater than the percentage on unknown words. A lower percentage of neologisms and phonological errors were also made on unknown words when compared to the percentage made on both known words and the words as a whole. The percentage of perseverative errors on unknown words represented more than twice that of the total words and three times that of the percentage on known words.

5.11.3 Pseudoword Error Types

Error types are more difficult to define for pseudowords and very few studies have attempted to consider them in detail. Semantic, derivational and neologistic errors cannot occur on pseudowords and no perseverative errors were made on pseudowords so only six error types were analysed. Many lexicalisation errors were made on the pseudowords in this study, so this particular type of error was investigated further. A significant result was obtained (Chi $X^2 = 24.39$, d.f. = 10, $p < 0.01$) which indicated that significantly more visual errors appear to occur on inconsistent type pseudowords in this study. There were insufficient lexicalisations on pseudohomophones to allow analysis to take place.

The lexicalisation errors made on pseudowords were also investigated solely in terms of body neighbours. It had been anticipated that significantly fewer lexicalisations might have occurred on unique type words as only one word would be available to be mistaken for the target, but no significant result was found.

Table 5.47 shows the distribution of errors across real words, both known and unknown, and lexicalisation errors on pseudowords and pseudohomophones as a percentage of the total errors made. They were calculated only on the error types which existed in all cases.

Table 5.47: Errors on Words and Pseudowords

Error Type	All Words	Known Words	Unknown Words	Pseudo-words	Pseudo-homophones
Visual	51.5	52.5	50	61.7	60.5
Phonological	20.4	23.5	15.3	10.8	14.7
I.L.	12.5	10.3	17.7	13.7	10.1
MDE	11.4	8.8	13.7	3.7	1.8
Letter-by-letter	1.4	1.5	0.8	5.0	6.4
No Response	0.8	0.5	1.6	4.6	5

A greater percentage of the errors on pseudowords and pseudohomophones were visual and letter-by-letter errors compared to the real word groups. There were many more no responses on pseudowords and pseudohomophones too. In addition to those no responses recorded above, there were also the participants who refused to attempt the pseudoword reading at all.

5.11.4 SUMMARY OF ERROR TYPE RESULTS

- Visual errors were the most common type of RA error and they were made particularly on high frequency words, inconsistent words and inconsistent pseudowords. 40% of those errors on real words occurred specifically on word onsets.
- Neologisms, phonological and perseverative errors were particularly apparent on low frequency words and the majority of the perseverations were made on words that were unknown to the participants.
- More of the derivational errors were made on words that were known to the participants.

- Very few LARC errors were recorded and of those made on irregular words, most of them were known to the participants.
- No particular type of error appeared to account for the unusually high number of errors on either unique or exception words.

All the findings described in this chapter are discussed in detail in the following chapter, Chapter Six.

CHAPTER SIX: DISCUSSION

6.1 INTRODUCTION

The overall aim of this investigation was to identify the most informative approach to the assessment of acquired reading aloud difficulties in people with dysphasia. Evidence from this study might then direct optimum programmes of remediation which might even have repercussions for improvements in other areas of language (Nickels, 1995).

Two major approaches to the study of reading aloud were discussed in Chapter Two: the modular dual-route and connectionist single-route theories. Their associated methods of word classification, regularity and body neighbourhood respectively, were also considered in detail. It is important to emphasize again that to differentiate the two theoretical stances purely in terms of their choice of word classification is to adopt a simplistic approach and that the findings of such a study will be of limited theoretical import. However, the aims of this investigation were clinically, not theoretically driven and concentrated on identifying the most satisfactory means of classifying, and thereby possibly explaining, the collected clinical data.

A series of studies has been presented, the results of which were examined both in terms of the number of errors on different categorisations of stimuli and in terms of error type analyses. Both aspects of the investigation have provided information about the reading aloud performance of people with dysphasia. However, with the exception of the influence of frequency, there appears to be no close relationship between the two.

6.2 CHAPTER OUTLINE

One of the main aims of this study was to determine if there is a difference in reading aloud performance on different word types and classifications by people with mild-moderate aphasia and if such a difference is more marked in the case of opposing body neighbourhoods or on the dichotomy of regularity. In section 6.3 the findings relating to these issues are discussed in detail. The findings are related to current models of reading aloud and the factors which may have affected the results in this study are considered. The question of whether or not people with dysphasia frequently know the meaning of the words which they read aloud incorrectly, and if this is particularly true of any specific word types, is also addressed. In section 6.4 the findings relating to both types of pseudoword stimuli are discussed and the relationship of such findings to the real word results is discussed in section 6.5. The types of errors which were made on reading aloud are dealt with in section 6.6 and the questions of whether or not error type is related to word type or knowledge of word meaning are also explored. Similarities and variations in the results across the whole series of tasks are discussed in section 6.7 and the issues which need to be considered when both devising and analysing such assessment tasks are identified. The final sections, 6.8 & 6.9 summarise the overall findings and draw conclusions about them and their implications for both current clinical practice and future research.

6.3 WORD CLASSIFICATION: DIFFERENCES IN PERFORMANCE

The first research question posed in Chapter One asked whether there is a difference in performance across different word types and classifications by people with mild-moderate dysphasia. The findings will be discussed first in terms of frequency and then regularity and body neighbourhood.

6.3.1 FREQUENCY

In both the VLD and RA tasks, performance on low frequency words was significantly poorer than on high frequency words. This effect was present regardless of whether or not the meaning of the RA stimuli was known to the participants. The two theories of reading aloud would both predict and accommodate such findings. Dual-route theorists claim that high frequency items have strong representations and as they can consequently be retrieved whole, direct from the lexicon, are less vulnerable to damage than lower frequency words. In single-route theories, such items are considered to have the strongest distributed patterns and so, once again, they are less vulnerable to damage.

The Frequency Hypothesis (c.f. 4.1.2) proposed that this investigation would identify a pattern of incorrect responses which could best be explained by a combination of frequency and one of the two methods of word classification. Although the results of this study with regard to frequency alone were predictable, based not only on the theories but also on the findings of numerous other studies, the fact that such results were obtained does support the importance of considering frequency in investigations of reading aloud. Consequently, the effects of frequency in this investigation will be considered further, but only in terms of their relationship with other methods of word classification.

6.3.2 REGULARITY

The results of the VLD task showed that, in this study, people with dysphasia found low frequency irregular words significantly more difficult to recognise as being real words than words of any other combination of regularity and frequency. The participants did not find low frequency irregular words significantly more difficult to read aloud accurately. However it should be noted that, although the difference was not significant in this instance, twelve of the fourteen participants did make more reading aloud errors on this category of words. The fact that only words of low frequency were in any way affected in these tasks again highlights the importance of regulating item frequency in any assessments of reading aloud.

It cannot necessarily be concluded that poorer performance on low frequency irregular words in the VLD study was due to the neurological damage suffered by the participants, as other studies suggest that the results may have been a consequence of the age of the participant population. Allen et al. (1993) found that older people tend to take longer to respond to items in VLD and are therefore more likely to be influenced by irregular spelling-sound correspondences than younger participants. Such an explanation suggests that poorer performance on low frequency irregular words could be due to the effects of aging rather than such words being particularly susceptible to neurological damage. Therefore, an explanation needs to be found for the difference in performance on these items in VLD and RA.

The following section will discuss the above findings in terms of dual-route theory, with particular emphasis on the possible explanations for the disparity in performance on low frequency irregular words in the two tasks.

6.3.2.1 Low Frequency Irregular Word Impairment: Dual-Route Explanation

According to dual-route theory, people with dysphasia will not necessarily find low frequency irregular words more difficult to identify or read than those words of any other category. Irregular words would only be expected to be particularly affected if neurological damage had affected the lexical route, the route believed to be responsible for generating whole word pronunciations for any real words already known to the reader. If the impairment to the route was only partial then it is argued that those words of low frequency would be most affected, as lexical storage of such items is considered to be less well established than those of higher frequency (Morton, 1967). Reading of regular words need not be affected by damage to the lexical route as their pronunciation can be correctly constructed via the non-lexical route.

6.3.2.2 Disparity in VLD and RA Results: Possible Causes

The Task Hypothesis (c.f. 4.1.2) proposed that results would be consistent across the tasks. The hypothesis is not supported by the findings with regard to low frequency irregular words, so the possible causes of the differences in performance on this group of words on the VLD and RA tasks must also be considered. If readers find it difficult to recognise a particular type of word, then it may seem unexpected that they should have less obvious difficulty pronouncing such words. This finding may, however, be attributed to a number of causes.

One explanation is that the difference may be due to the nature of the tasks rather than the stimuli items per se. If the theory which Balota and Chumbley (1984) put forward regarding the mechanism of VLD is accepted, then the reason that performance on low frequency irregular words was worse in VLD than in RA may be that the Familiarity/Meaningfulness (FM) (c.f. 4.2.2.3) criteria set by the participants was too exclusive and did not allow the correct identification of such words. This would seem to be a reasonable explanation as some of the irregular words e.g. *drachm* are orthographically unusual and might therefore have fallen outside of those criteria. Such an explanation neither supports nor disputes the regular-irregular categorisation as it relies solely on the appearance of the words and not on their phoneme-grapheme correspondences. Nor does it have any implications for the time-course model: if words were summarily rejected on account of the FM rating of their appearance then there would have been no further attempt to pronounce them. However, many other more common looking words e.g. *broad* were also rejected by the participants which suggests that such a result could not be due to inappropriately exacting FM criteria alone.

It is possible that the results do not indicate better performance on low frequency irregular words in RA compared to VLD. Instead, these findings may indicate that participants' performance on the other word groups was worse in RA than in VLD and consequently reading aloud of low frequency irregular words appeared less poor by comparison. This would appear to be a plausible explanation given that the majority of the participants *did* find the reading aloud of such low frequency irregular words more difficult than words of any other category.

If it is indeed the case that reading aloud performance is generally poorer across all the word groupings then this must be explained. Some time elapsed between participants taking part in the VLD and RA tasks and it might be argued that a particular participant was not performing at their optimum level when they took part in one of the tasks. Alternatively it might be that their seemingly improved performance on reading aloud compared to recognition of low frequency irregular words was indicative of a general improvement in their language abilities. However, it seems extremely unlikely that either would be the case in this instance as all the participants were so far post-onset of their CVA that neither neurological instability nor spontaneous improvement would be expected. As no participants showed any significant levels of dysarthria when tested on the Frenchay Dysarthria Profile and all were able to perform the Repetition task satisfactorily, dysarthria and phonological output difficulties, as well as neurological instability, can also be ruled out as possible causes.

Based on the views of Paap and Noel (1991), it might be suggested that as VLD is a lower level task it requires fewer resources and thus fewer word categories might be affected. RA is said to require greater general resources so overall performance might be expected to be poorer. However, this is a rather non-specific explanation which is not particularly informative in either clinical or theoretical terms. Although it would support the theory that, in this case at least, low frequency irregular words are the most vulnerable to degradation of any sort.

6.3.2.3 Dual-Route Explanation

Based on the VLD results, it has already been proposed that the lexical route might be affected in the participants of this study. Poor general word reading may indicate that damage has in fact occurred to both routes, with the low frequency irregular word deficit indicating that the lexical route is the more widely damaged.

6.3.2.4 Word Knowledge and Regularity

The Word Knowledge and Word Type Hypothesis (c.f. 4.4.2) proposed that the presence or absence of word knowledge would affect the number of errors that were made on different types of words. This hypothesis is not supported in the case of the regular-irregular dichotomy as the results of this task indicate that similar numbers of the incorrectly read regular and irregular words were unknown to the participants.

If all the irregular words which had been read aloud incorrectly were unknown to the participants then this might explain why they proved problematic to the participants - they would not be stored in the lexicon and a correct pronunciation could not be constructed via the non-lexical route. However, such semantic knowledge of regular words should be irrelevant if the non-lexical route were intact as a correct pronunciation could be constructed via this route independently of any semantic information. The fact that regular words were affected suggests that the non-lexical route must also be suffering from some level of impairment.

6.3.2.5 The Regular-Irregular Dichotomy Reviewed

Dividing words according to the classification of regularity failed to show a significant difference in RA performance across word type, whereas considering words in terms of the probability of their pronunciation did yield significant results. This fact suggests that the regular-irregular dichotomy fails to categorise items according to the most salient features affecting reading aloud performance. The only occasion on which significant results were obtained on the RA within the regularity classification was when four items were moved from the regular to irregular group. Three of these had relatively low probability scores, suggesting that it was the probability of pronunciation of these items rather than their irregularity that may have influenced the change in the findings.

These results indicate that spelling-sound correspondences do affect successful reading aloud, but that the regular-irregular dichotomy is simply not sensitive enough to the salient features. These results do not lead to the conclusion that regularity is a totally irrelevant means of word classification when studying the reading aloud behaviours of people with mild-moderate dysphasia. However, any relevance such a rigid system may have may be limited to those more severe and specific cases where more selective damage may be identified as having occurred. It appears that for the people with mild-moderate levels of dysphasia studied in this project there is a general level of impairment that is not best categorised or explained by means of regularity.

6.3.2.6 Clinical Implications

The discussion based on dual-route principles may provide an adequate explanation for the findings of the VLD and RA tasks, but it does not give a great deal of clinically useful information. The knowledge that both the lexical and non-lexical routes may be impaired to a greater or lesser extent in the same person does not offer a great deal of information when devising a therapy programme. Further, in-depth testing of the damaged routes might identify more specific areas of damage which would then facilitate the development of an appropriate therapeutic approach. However, such further assessments could only be considered useful if the classification system and concomitant theory were thought to be the optimum method of explaining word reading difficulties. The performance of people with dysphasia on the VLD task reflected normal pronunciation latency patterns, but no such strong pattern emerged in the RA data. This fact, combined with the probability of pronunciation findings, indicates that the regular-irregular classification employed by dual-route theory gives only limited information about the reading aloud abilities of this particular group of people. Indeed, the findings indicate that simple GPC is not sufficiently sensitive to the vagaries of word classification and that the dual-route model must allow for rather more complex levels of processing.

6.3.3 BODY NEIGHBOURHOODS

The Frequency and Word Type Hypothesis (c.f. 4.2.2) stated that frequency and word type would have a combined influence on the pattern of errors. Two main effects were found with regard to body neighbourhoods, a unique word effect which was strongest with regard to low frequency items and a high frequency exception effect, thus supporting the hypothesis in the case of frequency and body neighbourhood. The findings described in detail below and their implications for both dual- and single-route theories are also discussed.

6.3.3.1 Unique Word Effects

There were no significant body neighbourhood effects in the VLD task, although performance on low frequency unique words was notably worse than on items from other body neighbourhoods. Performance on the same low frequency unique word group was significantly worse in the RA task. On both instances, differences were found between low frequency consistent and unique words, whilst significant differences in performance on the RA task were also found between low frequency inconsistent and unique words. A marginally significant difference also occurred between performances on high frequency consistent and unique words.

The differences in performance on the low frequency consistent and unique words were readily accounted for. Further analysis of the individual stimuli showed that the low frequency unique words had a significantly lower mean frequency than the low frequency consistent words (c.f. 5.7.2.1), so this effect appears to be due to frequency alone and not due to any factors particular to a given neighbourhood. In addition, the RFM task showed that significantly more of the low frequency unique words were unknown to the participants when compared with the numbers of unknown low frequency consistent and inconsistent words. This finding explains why performance on low frequency inconsistent words was better than low frequency unique words, even though there was no significant difference in their mean frequencies. It also supports the findings with regards to the differing mean frequencies of the low frequency consistent and unique words, (the unique words have a lower mean frequency and would therefore be expected to be generally less well known to the participants than the consistent words).

In the case of the unique words there is little choice of stimuli as the members of this category are limited to a very small number, at least in the case of monosyllabic words. The only way to further investigate this effect would therefore be to attempt to select consistent words of a similarly low frequency and repeat the experiment to see if such an effect was still found. On the current evidence, it seems unlikely that such a strong effect would be replicated. Furthermore, identifying consistent words of such a low frequency would be difficult as they tend to occur in daily vocabulary more often than unique words. It is therefore unsurprising that the meanings of unique words were generally less well known than those words of the other body neighbourhoods. Again, this is due to the low frequency of occurrence of the words rather than to intrinsic qualities of the neighbourhood itself. However, the low frequency of particular items combined with the fact that such items are the only example of a given letter combination indicates that such patterns would have very weak representations and connections in any single-route model and so would be much harder to retrieve and also more vulnerable to damage than members of other word groups.

The notable difference in performance between high frequency consistent and unique words was not due to differences in mean frequency, as no such frequency differences were found amongst the high frequency words of differing neighbourhoods. The RFM task revealed that marginally significant differences were maintained between high frequency consistent and unique words which were known to the participants. That such differences also occurred between known high frequency inconsistent and unique words indicates that the differences amongst high frequency body neighbourhoods were not due to the influence of the frequency of the stimuli items per se. The effect must therefore be considered a Body Neighbourhood Effect. A plausible explanation for such an effect lies in the number, or possibly the frequency, of the other members of the stimuli items' body neighbourhoods. Consistent and unique items have no body neighbourhood enemies to oppose their correct pronunciation. However consistent words, particularly those of high frequency, have numerous body neighbourhood friends to support their pronunciation. As unique words have no such friends, it would seem reasonable to propose that the difference in performance across these two neighbourhoods is due to an effect of body neighbourhood friends. Such findings support the principles of single-route models, whereby the more friends an item has the greater the weights supporting its pronunciation will be. The findings also have implications for dual-route theory, indicating that it must be able to account for the influence on pronunciation of other similarly spelled items.

6.3.3.2 Exception Word Effects

A strong significant effect was found to occur between high frequency consistent and exception words. A weaker effect also occurred between high frequency inconsistent and exception words. This effect could not be explained in terms of a difference in mean frequency, as the mean frequency of the high frequency exception words was found to be no lower than that of the other groups. Nor could it be accounted for in terms of variable word knowledge across the different groups, as equal numbers of words from each neighbourhood were unknown to the participants. A higher proportion of errors was made on the high frequency exception words which were apparently known to the participants. This suggests that absence of semantic knowledge was not the cause for the poorer performance on high frequency exception words. It may indicate that the connections for exception words are more vulnerable to any damage that has occurred within the system. As Brown (1987) recognised, such words are the sole examples of a particular spelling pattern being pronounced in a particular way e.g. *pint* is the only example of -int being pronounced in a manner that does not rhyme with *mint*. Consequently, their connections may indeed be weaker.

The findings with regard to high frequency exception words were maintained throughout a number of post-hoc investigations. Performance on high frequency consistent words was still found to be significantly better when the inconsistent words were divided into inconsistent and gang words. The inconsistent-exception effect was not maintained in this instance. Both effects were however found to be stronger when the unique words were excluded from the analysis, indicating that the unique word effects caused largely by word frequency may mask exception effects in studies of this nature.

Coltheart and Rastle (1994) considered pronunciation latency scores for low frequency irregular words and proposed that the difference in scores could be accounted for by the differing position of the relevant irregular phonemes. The position of the phoneme responsible for the exceptional pronunciation in each of the high frequency exception words in this study was investigated. The findings were inconclusive as nearly all the words were exceptional at the second phoneme and errors were made on most of the words, regardless of the position of their exceptional phoneme. Coltheart and Rastle's work was concerned only with low frequency items and does not claim to impact on those of higher frequency. However their proposed dual-route explanation for the findings with low frequency words does not even allow for a finding involving high frequency words. Therefore, an alternative explanation is required for the high frequency exception word findings in this study.

The most plausible explanation for the high frequency exception word findings is a neighbourhood effect, involving the body neighbourhood enemies of this class of words. Jared (1997) found that performance was poorer on high frequency inconsistent words with low frequency friends and high frequency enemies, so it might then be predicted that high frequency exception words with no friends and high frequency enemies would be more affected. The high frequency exception words in this study had a much higher mean frequency of enemies than the low frequency exception words, which could explain why performance on the high frequency items was poorer than on those of low frequency when compared to the other neighbourhood categories. The difference in performance on high frequency consistent and exception words can be accounted for in terms of straightforward neighbourhood size effect, as consistent words have no enemies and many friends, whereas exception words have many high frequency enemies and no friends.

The interaction between high frequency inconsistent and exception words is more complex. Examination of the mean frequency of inconsistent word enemies shows that the mean for these is actually higher than the mean for high frequency exception word enemies. Based on Jared's findings, this would suggest that performance on high frequency inconsistent words should have been poorer than on the exception words. However, although the mean frequency of inconsistent word enemies is high, the frequency of inconsistent word friends is even higher. Thus, it would appear that the effect of friends outweighs the effects of enemies to the extent that inconsistent word performance is considerably better than performance on exception words.

The importance of neighbourhood friends found in this part of the study supports the conclusions about the poorer performance on high frequency unique words when compared to consistent words of similar frequency. The evidence regarding the importance of friends in the case of high frequency inconsistent words may indicate that poor performance on unique words was influenced by the absence of neighbourhood friends to support their pronunciation.

The findings discussed above suggest that factors connected to frequency, namely frequency of neighbourhood friends and enemies are major factors in the successful outcome of reading aloud. These findings support Jared's claims about the importance of frequency of body neighbourhood enemies and friends and as such have important theoretical and clinical implications. They support the classification employed by single-route theory as being more effective in explaining the clinical data obtained in this study and also indicate that dual-route theory fails because it does not take account of the influence of similar words on reading aloud performance on any given word. However, it is important to recognise that neighbourhood factors alone are not a sufficient explanation for all reading aloud difficulties - if they were then all the errors on the high frequency exception words would have involved influences from their neighbourhood enemies, i.e. exception words would have been given the body pronunciation of their inconsistent partner(s). As the later discussion of error types will show, this rarely proved to be the case.

6.3.3.3 Word Knowledge and Body Neighbourhood

The Word Knowledge and Word Type Hypothesis (c.f. 4.4.2) proposed that the spread of errors would be explicable in terms of the presence or absence of knowledge of the meaning of particular stimuli items. It was certainly the case that more of the low frequency unique words on which errors were made were unknown to the participants. However, lack of word knowledge was unable to account for either the high frequency exception effects or the poorer performance on low frequency irregular words.

6.4 PSEUDOWORD RESULTS

The following section will discuss in detail the findings which relate to the pseudoword stimuli. Three main types of non-word stimuli were used in the

Response Time task. Two groups of stimuli, common pseudowords and pseudohomophones followed both the orthographic and phonotactic rules of English, whilst the third was composed of items which did not conform to either. Only the former two groups were used in the tasks of the main study and it is the results relating to them which will be discussed here (findings relating to the third group and the reasons for their exclusion from other tasks can be found in Chapter Two).

The principle reason for including pseudowords of any sort in the study was to investigate what, if any, comparisons could usefully be made between performance on them and on real word stimuli. The Pseudoword Hypothesis (c.f.4.1.2) proposed that the pattern of errors on pseudoword stimuli would reflect the pattern of responses found on the real word stimuli. Apart from the RT task, mentioned above, these stimuli were included in the VLD, RA and Repetition tasks. By their very nature, as non-lexical items, they could not be included in the RFM task. Performance on each of the two groups of pseudoword will be considered first, followed by a comparison across the two groups and then with performance on the real word stimuli. The concluding part of this section will concentrate on discussing the value of including such stimuli in any comprehensive assessment of reading aloud ability.

As was discussed in Chapter Two, pseudowords have only real word friends not enemies, so whereas four types of neighbourhood were considered with regard to real words, pseudoword investigations consider only three – consistent, inconsistent and unique. The category of exception is rendered obsolete by dint of the fact that pseudowords cannot be assumed to have a fixed pronunciation and the pseudoword *kint* could, for example, have been created from either *mint* or *pint* and pronouncing it to rhyme with either would have to be considered acceptable.

6.4.1 PSEUDOWORDS

The VLD task showed no difference in performance across the different body neighbourhoods, i.e. no particular body neighbourhood type in this study was particularly prone to being misclassified as a real word. In contrast, an effect of body neighbourhood was found to occur in the RA task. Both consistent and inconsistent type pseudowords were given an acceptable pronunciation significantly more frequently than unique type pseudowords. Further analysis revealed that, of those 89% of pseudowords which were given a predictable, body-based pronunciation, significantly more of them were of the consistent and inconsistent type of pseudowords than of the unique type. Of those pseudowords which were not awarded an acceptable pronunciation, many received a pronunciation that was near to the correct and, again, significantly more consistent and inconsistent type items were in this group than unique type items.

6.4.2 PSEUDOHOMOPHONE RESULTS

No significant difference by body neighbourhood type occurred in the VLD. However, as in the case of pseudowords, a significant effect was found in the RA task which indicated that performance on unique type pseudohomophones was poorer than that on consistent and inconsistent type items.

6.4.3 PSEUDOWORD AND PSEUDOHOMOPHONE RESULTS: AN EXPLANATION

In the case of both common pseudowords and pseudohomophones, no significant effect of body type was found in the VLD and a significant result was found in RA which in all cases indicated that performance on those non-words based on unique words was poorer than performance on consistent and inconsistent type items. A plausible explanation for this finding would have been that the unique type non-words on which the most errors were made were the ones which were based on low frequency unique real words. Such differences in performance could then have been accounted for as being due simply to a frequency effect. However, investigations showed that neither pseudowords nor pseudohomophones created from low frequency unique words were more prone to errors than those based on high frequency words. Therefore, frequency per se cannot be held responsible for poorer performance on this neighbourhood of pseudowords. As performance on unique type pseudowords was poorer than that on pseudowords of other neighbourhood types and, as this result is not related to the frequency of the words on which they are based, these findings suggest that an effect of frequency may not have been entirely sufficient to explain the findings with regard to real unique words.

The fact that the unique type pseudowords were significantly less likely to receive an acceptable pronunciation would be predicted by those who support classification by neighbourhood. As the neighbourhood group with only one real word friend to support their pronunciation, it is predictable that unique type pseudowords should be at a disadvantage to those groups which have considerably larger numbers of real word supporters. The pseudohomophones were homophonic based on neighbourhood pronunciations e.g. *poap* would sound like *pope* only if it were pronounced to rhyme with *soap* and not if it were broken down letter by letter. The fact that fewer of the items based on unique words were pronounced correctly indicates the influence of real words on pseudoword pronunciation and also supports the conclusion that performance on unique words is poorer because of an absence of neighbourhood friends.

The conflict that may arise in the attempt to read aloud inconsistent type pseudowords is rendered irrelevant as there is no one correct pronunciation to be identified, unlike with the inconsistent/exception dilemma that occurs with real words. However, performance on inconsistent type pseudowords might still be expected to be affected by the fact that more than one possible pronunciation is available compared to consistent type items where no such options occur. Whilst a study of pronunciation latency might indeed indicate that this is the case, in this investigation the reverse appears to be true. The significant difference in performance between inconsistent and unique type pseudowords was greater than that between consistent and unique type pseudowords which suggests that performance on inconsistent type pseudowords was better than performance on consistent type pseudowords. No immediate explanation for this is apparent, although it may be that as a greater number of pronunciation options exist for these items, there is a higher probability that they will be assigned an acceptable pronunciation. The findings with regard to pseudoword items in this particular study do appear to support the importance of the effects of neighbourhood friends as well as enemies.

6.5 COMPARISON OF REAL AND PSEUDOWORD RA PERFORMANCE

In the RA task, the reading aloud of pseudowords and pseudohomophones did, to some extent, reflect performance on real words. The evidence suggests that, for all three groups of stimuli, unique type items are particularly vulnerable to neurological damage. Whereas for low frequency real words this difficulty can be attributed largely to the influence of frequency itself, the same is not true for either high frequency words or the pseudoword and pseudohomophone items. Therefore, the most reasonable explanation for this effect would appear to be the absence of neighbourhood friends in real words and the existence of only one real word friend for the non-word items. Whilst this trend appears to co-occur over all the stimuli groups, the very nature of the non-word stimuli renders it impossible to consider them in terms of either regularity or the full spread of body neighbours. Hence, information from pseudoword data cannot contribute to evidence gained from real words regarding the regular-irregular dichotomy or the vulnerability of high frequency exception words that was identified in the real word RA data. However, it is evident that real word neighbourhoods do influence the pronunciation of pseudowords. This further disputes the validity of dual-route theory which uses pseudowords to determine non-lexical route functioning but does not allow for the interaction of real word information in the deriving of pronunciations for pseudowords.

6.6 ERROR TYPES

The Error Type Hypothesis stated that word type would influence the types of errors which were made on words that were not read aloud correctly (c.f. 4.3.7). No significant relationship between word and error types was identified, however the pattern of error types does suggest that error type may be influenced to some extent by body neighbourhood.

6.6.1 REAL WORD ERRORS

Predictably, more neologisms, phonological and perseverative errors were made on low frequency words. However, the fact that many of the perseverations occurred on words unknown to the participants is worthy of note. This finding indicates that perseverative errors may not be occurring because a client has simply become locked on one production, but rather that this fixation has occurred due to a lack of knowledge of the target items. It is possible that if the participants who produced these errors had known the words involved then they may have been able to over-ride their tendency to perseverate. This suggestion is supported by the fact that they were able to read large numbers of the items without perseverating, so it was not a problem which was continually manifested in their reading aloud performance. Therefore it might have been exacerbated by lack of word knowledge.

More visual errors were made on high frequency words indicating that frequency may influence error type. Future investigations may wish to explore whether the actual words produced were of a still higher frequency than the target items. This might give some indication of what influenced the selection of the incorrect items.

Visual errors accounted for the greatest percentage of errors on all the body neighbourhood types, but this percentage was particularly high for exception and inconsistent words (c.f. Table 5.44). This fact, combined with the fact that a considerable percentage of the visual word errors (40%) involved mistakes that related specifically to the body of the word suggests that body neighbourhood may exert some influence on the production of visual errors. Exception and inconsistent words are the two types of neighbours, in this study, where a conflict of pronunciation may occur. Further investigations of the links between these neighbourhoods and visual errors may have implications for possible therapeutic approaches.

Derivational errors formed a particularly high percentage of the errors which were made on words which were known to the participants. This might be argued to support the link between derivational and semantic type errors that was discussed in Chapter Four. This connection between the two error types could be further supported if therapeutic intervention on one was found to affect performance on the other.

The lack of production of semantic errors in this study may be indicative of several factors. It may be that none of the participants tended towards the syndrome of deep dyslexia (the only syndrome in which the production of semantic errors is particularly marked). It may be that the focus of the literature towards such errors is not warranted in the case of mild-moderate dysphasics. Or it may be that, as the participants in this study were at least a year post-onset of their CVAs, any cases of deep dyslexia had resolved into phonological dyslexia (as advocated by Glosser and Friedman, 1990).

6.6.2 PSEUDOWORD ERROR TYPES

The one significant result which was obtained in relation to pseudowords and error types was that significantly more visual errors were made on inconsistent type pseudowords and, as was discussed in 6.6.1, a similar result also occurred on inconsistent real words. This further confirms the suggestion that the conflicting pronunciations available for the body of an inconsistent word may have some relationship with the production of visual errors. This finding also offers support to the Pseudoword Hypothesis (c.f. 4.1.2) which stated that performance on pseudowords would be similar to that on real words and indicates that the body neighbourhood of a pseudoword may have some influence on reading aloud performance.

An investigation was carried out into the nature of lexicalisation errors on pseudowords and pseudohomophones. It is of no surprise that the majority of these errors (60+ %) were visual in nature. However this finding does suggest that if so many pseudoword reading errors are visual in nature (as are so many real word reading errors), then the assumption of many researchers that incorrect pseudoword reading is indicative of disruption at complex levels of functioning appears to be unsupported. Instead, it seems that pseudowords are simply prone to the same types of visual influences as real words.

It was anticipated that fewer lexicalisations would occur on the unique type stimuli than on the other types of pseudowords. This prediction was made on the basis that unique type pseudowords would have fewer lexical influences, having only one real word body neighbour. The fact that this was not the case may reflect a number of issues:

- If the real word unique stimuli were unknown to the participants then they would be unable to make the analogy as no pattern or word would have been stored which contained the orthography of the pseudowords' body.
- Lexicalisations are made more often on pseudowords based on high frequency words and this frequency effect masks any effect of body.
- Lexicalisation errors may simply reflect lack of attention on the part of the participants, so they occur randomly across word types.

The investigation of pseudoword error types is not a common approach to the exploration of pseudoword reading difficulties. This study has performed only a preliminary investigation, but the results suggest that a more in-depth investigation may provide further information about the processing of pseudowords. Such information could have important implications for the use and analysis of pseudowords in tests of reading aloud.

6.6.3 SUMMARY OF ERROR TYPE RESULTS

This study considered the types of reading aloud errors made on both words and pseudowords. Only fourteen people took part in the investigation and they produced a wide range of error numbers and types. In order to draw any strong conclusions, greater numbers of participants would be necessary. However, the preliminary indications are that frequency and body neighbourhood may be related to error type, particularly visual errors. Although some of the error types (e.g. inital letter errors) are specific to reading aloud skills, others (e.g. semantic, derivational) may also occur in other aspects of language functioning, such as naming and spontaneous speech. Therefore, the identification and remediation of such errors in reading aloud may arguably have ramifications on general language performance. As such, it is argued in this study that more emphasis should be placed on the identification and remediation of error types in clinical practice.

6.7 TASKS

The results of various tasks have been presented and their findings discussed with regard to the differing methods of word classification under investigation. The following discussion will focus on the tasks themselves and their contribution to the investigation of reading aloud. Two of the tasks, Visual Lexical Decision and Reading Aloud, are commonly used in the assessment of the word recognition and reading aloud abilities of people with dysphasia. A third task, Reading for Meaning aimed to determine the word knowledge of participants. Investigation of semantic awareness is also a frequently used approach to assessment, however the RFM task employed here was a novel one devised particularly for this study in an attempt to evaluate the participants' understanding of some of the stimuli items from the aforementioned reading aloud task. A further method, the Response Time task is not generally used in any form of assessment of dysphasia. However, it is frequently used in studies of normal processing involving participants with no known impairments. The specific purpose of using it in this study was not only to generate data for this particular project, but also to provide methodologically useful information regarding its possible wider employment in the study of dysphasia.

The following sections will summarise the findings of the above investigations and evaluate their clinical value both as individual tasks and as a combined, complementary assessment battery. Aspects of the methodology that may have influenced the results in this particular study, or that the findings suggest should be considered in future investigations using similar tasks, will also be highlighted.

6.7.1 THE RESPONSE TIME TASK

Methodological issues relating to the results of this task have already been discussed in Chapter Three, so only a brief summary will be provided here. The often practical difficulties in terms of clinical availability of equipment aside, the difficulties of accurate measurement due to greater hesitancy, self-correction and the underlying motor speech difficulties which are common in people with dysphasia restrict the value of this task and its results with regard to people with dysphasia. This task is widely used in the study of normal processing but in this instance its limitations are clear.

However, in this study this task has allowed comparison to be made between the performance of normal and impaired participants. Although no indication was given of the high frequency exception effect found in the RA task, the results with regard to unique words do suggest that there is some validity in equating the number of errors made by participants with dysphasia with normal response times, allowing researchers to make links between similar behaviours and processing mechanisms.

6.7.2 THE VISUAL LEXICAL DECISION TASK

The results of this task showed a highly significant effect of regularity which was found to be confined to low frequency items. Specifically, low frequency irregular words were most often misclassified as pseudowords. Much weaker evidence was found with regard to body neighbourhoods. The results were again restricted to low frequency words, this time of the unique word category.

The protocol used for this task was similar to that used in standard experimental versions of this task. However, it was not timed so participants had as long as was necessary to make their decision. This approach was chosen as such speeded responses are not required of people in real life settings and the aim of all the tasks in this study was to identify what the people with dysphasia were able to do in such contexts. In future studies of this nature, it would be useful if all the incorrectly identified real word VLD items were included in the RFM task as such information might provide additional insight into the errors made.

One difficulty that became apparent in the use of this task was that people with dysphasia were often unable to inhibit their reading aloud of the test items. This changes the nature of the task as it is no longer one of visual word recognition, but rather aural word recognition. If an item was read aloud incorrectly by a participant then this in turn might have affected the decision which the candidate made regarding the word/pseudoword status of that item. This is not a fault of the methodology of this particular task, but rather a consequence of the nature of dysphasia. Regular reminders were given to participants where necessary, but were insufficient to eradicate the difficulty. This issue calls into question the validity of the data collected from the VLD task in this particular study. It also questions the value of the VLD task as a general assessment tool for people with dysphasia.

6.7.3 READING ALOUD

No significant difference was found in participants' ability to read aloud regular and irregular words of any frequency. As has already been discussed, the low frequency irregularity effect of the VLD task was not replicated here.

In contrast to the VLD task, several strong body neighbourhood results occurred here. The VLD task had indicated that low frequency unique words might be a vulnerable subgroup and this proved to be the case in this task. High frequency exception words also fared poorly in this task. This result was not due to low mean frequency or lack of word knowledge as was the case with the low frequency unique words. Although VLD appeared to give an indication of some of the results that might be expected to be found in reading aloud, it only predicted the ones which were due to issues of frequency and word knowledge, and as such was not particularly helpful.

People with dysphasia showed no evident difficulties with coping with the methodology of this task. The necessity of splitting the lists and presenting them on regarding the word/pseudoword status of that item. This is not a fault of the methodology of this particular task, but rather a consequence of the nature of dysphasia. Regular reminders were given to participants where necessary, but were insufficient to eradicate the difficulty. This issue calls into question the validity of the data collected from the VLD task in this particular study. It also questions the value of the VLD task as a general assessment tool for people with dysphasia.

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People with dysphasia showed no evident difficulties with coping with the methodology of this task. The necessity of splitting the lists and presenting them on three separate occasions to avoid priming would mean that the presentation time of this test might have implications for clinical use in its present form. Repeating the task with the same group of participants, after a given period, might provide additional information. It would be interesting to see whether or not participants made errors, particularly the same type of errors, on the same words or on the same categories of words. Errors on exactly the same stimuli would indicate that it was those particular items, rather than their classification, that were responsible for the difficulties, whereas errors on the same categories of words would be a strong indication of the particular vulnerability of the categories concerned and as such might have implications for the importance of a particular method of classification.

6.7.4 READING FOR MEANING

This task had a greater number of specific aims than any other individual task in this study. It aimed not only to determine if participants knew the words on which they made errors, but also if the presence or absence of this knowledge affected the spread of errors across the different word types. The task identified that lack of word knowledge played a part in the poor performance on low frequency unique words, but it did not contribute any additional information to the investigations into high frequency exception word effects. Failure to find any relevant information may have been due to one of two causes:

- **The Task does not Test Word Knowledge**

  There are a number of methodological issues which may mean that the task failed to truly test word knowledge. The alternative definitions for each word were matched for length, but not semantically or visually and this may have enabled some false positive scores to occur. False positives may also have occurred because some participants were able to identify the meaning of a given item by a process of elimination, for example "I know that this word is not *x* or *y* and therefore it must mean *z*". However, the task does give a baseline for a lack of knowledge, for example it can be determined that participant *A* did not know at least *n*% of the words which he/she read aloud incorrectly and this at least is useful information.

- **Knowledge of Word Meaning may not be Central to Successful Reading Aloud**

  It would appear that word knowledge does not have a major effect on the results of this investigation. Based on the results of the neighbourhood investigations, it would appear that familiarity with an item's body neighbours is the most important factor.

The final issue pertaining to the effectiveness of this task is the same as that found in the VLD task, some participants were unable to inhibit pronunciation of the items being tested and their spoken responses may arguably have influenced their choice of semantic definition.

In the light of the above conclusions, the value of such an investigation must be carefully considered. If it is indeed the case that semantic knowledge truly has little relevance to the results of such tasks then testing such knowledge is unnecessary. If however it is considered that the results are affected by the factors in the above discussion then resolution of these may increase the value of the task.

6.7.5 THE USEFULNESS OF THE TASKS: CONCLUSIONS

This project has studied reading aloud alongside both the lower level activity of visual word recognition and the higher level of semantics. It indicates that there are some harsh conclusions to be drawn regarding the varying usefulness of the tasks involved.

The VLD and RT tasks are useful in that they allow some comparison with the performance of people without language impairment, but they have severe limitations when used with this population due largely to the response mechanisms of people with dysphasia. The RFM task also produced some useful findings, but many limitations were identified in its implementation. It requires further testing and greater reference to other similar tasks before further conclusions can be drawn regarding its use in this type of study. If the stimuli are closely controlled, as in this project, then the results of this study suggest that the RA should be sufficient to comprehensively assess reading aloud ability in terms of current theoretical knowledge of the factors affecting reading aloud.

6.8 IMPLICATIONS FOR CLINICAL PRACTICE AND FUTURE RESEARCH

The findings of this study have indicated that the reading aloud performance of people with dysphasia can be explained more comprehensively by the use of body neighbourhoods, rather than the regular-irregular dichotomy, as a means of word categorisation. The findings of this study are likely to be more representative of the abilities of the general dysphasic population as the participants in this study were a group of people with the mild-moderate type of dysphasia commonly found in clinical patients rather than the very specific, isolated single cases which are reported in the literature. In this group of people at least, performance was significantly poorer on low frequency unique words and high frequency exception words. Both of these findings have some implications for the use and interpretation of stimuli in clinical assessments. The large number of errors on low frequency unique words was due in part to the significantly lower frequency of these items compared to the low frequency items in other body neighbourhoods. Participants' lack of familiarity with more of those particular stimuli than the words from other categories also influenced performance. These findings emphasise the importance of considering frequency when choosing stimuli and that the choice of unusual words may influence the results. The high frequency exception word effect also has implications for clinical practice. It indicates the importance of body neighbourhood friends and enemies and indicates that they too should be accounted for in any assessment.

There are many factors to be considered regarding the use of body neighbourhood as a means of word classification for clinical assessment. This study has indicated that difficulties on unique words may cloud the results of other groups and so their inclusion in any such assessment must be considered. In order to make the assessment as straightforward as possible for clinicians, equal numbers of stimuli would have to be included in each sub-set so that a simple error count could be used to obtain meaningful results, rather than complex statistical tests which would be impractical and unnecessary for clinical use.

The issue of the clinical relevance of the results must also be considered. It is necessary to consider what clinical impact the finding actually has that high frequency exception words with high frequency enemies are most susceptible to damage. The findings of this study and that of Jared (1997), may have supported the possible psychological reality of body neighbourhoods as a means of lexical storage but the clinical implications of this must also be considered. Much work needs to be done before these findings can be implemented clinically. Further testing is required to ensure that these findings can be replicated with different stimuli and greater numbers of the population.

Plaut (1996) has already indicated that the single-route model may be able to identify suitable items to be used as stimuli and those that will benefit most from remediation, but further investigation is required of these claims. The only study so far which has made mention of the type of classification employed by body neighbourhoods is that by Byng and Coltheart (1989), which was one of those listed by Nickels (1995) as indicating that reading rehabilitation may have widespread effects on language functioning. Further studies of this type need to be undertaken to see if such findings can be replicated.

A more complex question is how the single-route model itself may be clinically applied. The dual-route model is well established in clinical practice and the cognitive neuropsychological model of which it is part has been found to have widespread applications not only to adults with dysphasia but also to developmental studies and people with learning disabilities. However, the evidence from this study does not support the regular-irregular dichotomy on which it is based. To date the single-route model is less widely established, although similar models are increasingly familiar in the study of speech production (Dell, 1997).

The single-route model does not have the convenient modularity of the cognitive neuropsychological model and thus it is likely to be less clinically appealing than its dual-route rival. Its emphasis on the combined workings of the reading system, rather than on the separated routes, make the identification of specific areas of deficit more difficult. It may, as Seymour (1992) advocated, reduce the emphasis on the classification of dyslexia by syndrome, but it is not yet clear what it offers in place of this. In order to be able to assess whether working on reading improves other functional areas of language, it is necessary to be able to assess those other areas both pre- and post-therapy in a structured manner. The cognitive neuropsychological model allows this, as yet the single-route does not. The single-route model of reading has concentrated on a small and easily distinguishable area of language processing and the findings may well be more exacting than those of the dual-route model classifications, but for this to be of anything more than theoretical interest a method of utilising these findings in a clinical assessment and therapeutic programme must be identified.

One possible way of incorporating the single-route model into clinical practice is to consider it as changing the microstructure rather than the macrostructure of the cognitive neuropsychological model. Any model of reading aloud must include a visual input stage, some means of lexical look-up or word processing and an output stage, so the principal aspects of the cognitive neuropsychological model could remain unaffected by any change in bias with regard to the means of word categorisation. However, this would not be a straightforward change as the findings of this study do question the validity of a two route model, so adaptations would be necessary to eradicate the whole-word route in its current incarnation. Such changes would have the advantage of switching the emphasis of assessments from comparing the performance of one route against another towards identifying the level of breakdown along a continuum of dysfunction.

The use of models of normal reading for identifying difficulties in people with dysphasia must also be carefully considered. The findings of studies using unimpaired participants rely heavily on the use of pronunciation latency tasks, this study has shown the practical difficulties of using such methods with people with dysphasia and although it may arguably be valid to equate response times with error counts, it must be recognised that the two are very different methods of assessment.

Error types may be the most relevant finding to clinicians wishing to work on reading aloud difficulties. Visual errors may indicate the need to increase the client's ability to concentrate and pay close attention to his attempts, where previously when in good health this was unnecessary. Phonological errors may indicate difficulties at a number of levels and further investigation of these followed by remediation may improve the intelligibility of spontaneous speech. A decrease in semantic errors over time may indicate a shift in the client's neurological functioning as identified in PET scans (c.f. 2.2.1) and the evolution of phonological dyslexia from deep dyslexia. Focus on initial letter correct reading may identify issues of foveal splitting or neglect, or inattention as for visual errors. The results of this study indicated that lack of word knowledge may be the underlying cause of many perseverative errors, so work on semantics may reduce the occurrence of such errors in both reading aloud and spontaneous speech. Letter-by-letter reading may enable the use of phonological cues which would also help to overcome no responses. Multiply derived errors may be harder to remediate, although work on visual and/or phonological work might reduce them to the status of semantic errors.

6.8.1 FUTURE INVESTIGATIONS: A SUMMARY

The findings of this study have indicated a number of theoretical and clinical issues which need to be addressed by future investigations:

- Further investigations need to be carried out with greater numbers of participants to ensure that these findings can be replicated. The clinical implications discussed in this study could then be more widely applied
- The use of neighbourhoods in the remediation of the reading aloud difficulties of people with dysphasia should be explored
- Greater emphasis on the investigation of error types as well as the types of words on which errors are made may prove to be clinically informative

- More detailed investigation of pseudoword error types and the approach of people with dysphasia to this type of stimulus may inform the manner in which these items are used in the assessment of reading aloud
- Investigation of the relationship between body neighbourhood and probability of pronunciation scores may prove useful as these two aspects of word classification appear to be the strongest indicators of reading aloud success and together may be informative to the further development of theories of reading aloud
- The relevance of the findings of this study to the reading aloud of polysyllabic words also needs to be investigated, so that the conclusions can be more widely applied

6.9 CONCLUSION

The main aims of this study were to identify the optimum method of classifying reading aloud errors and to investigate the underlying nature of those errors by considering the influence of semantics and the actual error types involved.

The null hypothesis, that there would be no differences in the abilities of the classifications of regularity and consistency to provide a comprehensive account of single word reading aloud difficulties, is not supported. Performance on different word-types did distinguish between a regular-irregular dichotomy in the VLD task but not in the RA task. Whereas differences in performance on body neighbourhoods were evident in both the VLD and in the RA task, they were considerably stronger in the latter task. As the Frequency and Word Classification Hypothesis proposed, effects of frequency were also central to those results.

Although it was the cumulative frequency of the body neighbourhood friends and enemies of the word groups in question that were identified as being responsible for many of the findings rather than the frequency of the individual stimuli items.

Significantly poorer performance occurred on low frequency unique and high frequency exception words and the probability of a word's pronunciation was also found to be a significant indicator of the success of reading aloud performance. Exception words appear to be more sensitive to the difficulties of people with dysphasia than the more widely used irregular word class. The results of this study indicate that words must be considered not just in terms of their own regular or irregular pronunciation, but also with regard to the pronunciation of other similarly spelled words. The findings point away from the more rigid dual-route structure towards the value of a more flexible distributed model which is able to account for the influence of other similar words on the pronunciation of a particular item.

APPENDIX ONE

In this appendix, the real word stimuli items are grouped in terms of their body neighbourhood and then sub-grouped according to their regularity and frequency. It was decided to first categorise the words by body neighbourhood as all the pseudoword stimuli could also be organised in this manner.

REAL WORD STIMULI

Word	Body	Regularity	Frequency	Probability Score
BOAT	Consistent	Regular	High	1
COAST	Consistent	Regular	High	1
CORN	Consistent	Regular	High	0.96
FACT	Consistent	Regular	High	1
FREE	Consistent	Regular	High	1
GANG	Consistent	Regular	High	1
GIRL	Consistent	Regular	High	0.81
MILE	Consistent	Regular	High	1
MILK	Consistent	Regular	High	1
MILL	Consistent	Regular	High	1
NECK	Consistent	Regular	High	1
QUICK	Consistent	Regular	High	1
RAIL	Consistent	Regular	High	1
REIGN	Consistent	Regular	High	0.93
SCENE	Consistent	Regular	High	0.93
SCENT	Consistent	Regular	High	1

Word	Body	Regularity	Frequency	Probability Score
SINK	Consistent	Regular	High	1
SORT	Consistent	Regular	High	0.81
SPEND	Consistent	Regular	High	1
STIFF	Consistent	Regular	High	1
TAKE	Consistent	Regular	High	0.75
TROUT	Consistent	Regular	High	0.92
TURN	Consistent	Regular	High	0.8
BUG	Consistent	Regular	Low	1
DUEL	Consistent	Regular	Low	0.67
GIST	Consistent	Regular	Low	0.89
GNAW	Consistent	Regular	Low	1
GRIT	Consistent	Regular	Low	1
GULP	Consistent	Regular	Low	1
HOAX	Consistent	Regular	Low	1
KNELT	Consistent	Regular	Low	1
KNOB	Consistent	Regular	Low	0.94
LARK	Consistent	Regular	Low	0.79
MESH	Consistent	Regular	Low	1
NIECE	Consistent	Regular	Low	0.77
PINCH	Consistent	Regular	Low	1
PSALM	Consistent	Regular	Low	0.71
QUILT	Consistent	Regular	Low	1
RUB	Consistent	Regular	Low	1
SLATE	Consistent	Regular	Low	1
SPADE	Consistent	Regular	Low	1
WEPT	Consistent	Regular	Low	1
DANCE	Consistent	Irregular	High	0.67
SURE	Consistent	Irregular	High	0.35
BARGE	Consistent	Irregular	Low	0.68

Word	Body	Regularity	Frequency	Probability Score
BLIGHT	Consistent	Irregular	Low	1
CLIQUE	Consistent	Irregular	Low	0.56
SLAIN	Consistent	Irregular	Low	1
WEDGE	Consistent	Irregular	Low	1
BOMB	Exception	Regular	High	0.74
CLIMB	Exception	Regular	High	0.78
GAS	Exception	Regular	High	1
GILD	Exception	Regular	High	1
GOLF	Exception	Regular	High	0.96
HAS	Exception	Regular	High	0.71
HUGE	Exception	Regular	High	0.85
LIMB	Exception	Regular	High	1
SCARF	Exception	Regular	High	0.83
TOOTH	Exception	Regular	High	1
WAR	Exception	Regular	High	0.8
WARD	Exception	Regular	High	0.76
WAS	Exception	Regular	High	0.43
WORD	Exception	Regular	High	0.79
WORM	Exception	Regular	High	0.96
WORSE	Exception	Regular	High	0.75
COMB	Exception	Regular	Low	1
FARCE	Exception	Regular	Low	0.59
GRIEVE	Exception	Regular	Low	1
GUISE	Exception	Regular	Low	0
NINTH	Exception	Regular	Low	1
PLINTH	Exception	Regular	Low	1
QUIT	Exception	Regular	Low	1
SWAMP	Exception	Regular	Low	0.83
WAND	Exception	Regular	Low	0.79

Word	Body	Regularity	Frequency	Probability Score
WARN	Exception	Regular	Low	0.76
WASP	Exception	Regular	Low	0.79
ARE	Exception	Irregular	High	0.52
AUNT	Exception	Irregular	High	0.68
BOWL	Exception	Irregular	High	1
BREAST	Exception	Irregular	High	0.9
BROAD	Exception	Irregular	High	0.93
CLERK	Exception	Irregular	High	0.8
COUP	Exception	Irregular	High	0
DEAF	Exception	Irregular	High	0.84
DOUGH	Exception	Irregular	High	0.77
GREAT	Exception	Irregular	High	0.76
GROSS	Exception	Irregular	High	1
HAVE	Exception	Irregular	High	0.73
HEIGHT	Exception	Irregular	High	0.72
PINT	Exception	Irregular	High	0.93
SCARCE	Exception	Irregular	High	0.68
SWEAT	Exception	Irregular	High	0.88
TOUCH	Exception	Irregular	High	0.7
WERE	Exception	Irregular	High	0.79
WOLF	Exception	Irregular	High	0.75
WOOL	Exception	Irregular	High	0.89
BROOCH	Exception	Irregular	Low	0.88
BURY	Exception	Irregular	Low	1
CASTE	Exception	Irregular	Low	0.76
FLANGE	Exception	Irregular	Low	0.75
HEARTH	Exception	Irregular	Low	0.77
LOUGH	Exception	Irregular	Low	0
LUGE	Exception	Irregular	Low	0.38

Word	Body	Regularity	Frequency	Probability Score
SEW	Exception	Irregular	Low	0.54
SEWN	Exception	Irregular	Low	0.69
SIEVE	Exception	Irregular	Low	0.68
WEIR	Exception	Irregular	Low	1
BLEAK	Inconsistent	Regular	High	1
COST	Inconsistent	Regular	High	1
CROSS	Inconsistent	Regular	High	0.94
DEAR	Inconsistent	Regular	High	1
DOME	Inconsistent	Regular	High	1
FEAST	Inconsistent	Regular	High	1
FOOL	Inconsistent	Regular	High	1
FORM	Inconsistent	Regular	High	0.81
FURY	Inconsistent	Regular	High	0.92
GAVE	Inconsistent	Regular	High	1
GO	Inconsistent	Regular	High	1
HEIR	Inconsistent	Regular	High	0.78
HERE	Inconsistent	Regular	High	0.93
JAR	Inconsistent	Regular	High	0.71
LEAF	Inconsistent	Regular	High	1
MILD	Inconsistent	Regular	High	0.78
MINT	Inconsistent	Regular	High	1
POST	Inconsistent	Regular	High	1
SHARE	Inconsistent	Regular	High	0.69
SMOOTH	Inconsistent	Regular	High	0.84
SUIT	Inconsistent	Regular	High	0.83
TONE	Inconsistent	Regular	High	1
TREAT	Inconsistent	Regular	High	1
WEIGHT	Inconsistent	Regular	High	1
BEAD	Inconsistent	Regular	Low	1

Word	Body	Regularity	Frequency	Probability Score
BOUGH	Inconsistent	Regular	Low	0.63
BREW	Inconsistent	Regular	Low	1
BRUISE	Inconsistent	Regular	Low	1
CON	Inconsistent	Regular	Low	0.94
DIVE	Inconsistent	Regular	Low	1
GLAND	Inconsistent	Regular	Low	1
GRANGE	Inconsistent	Regular	Low	0.91
GROWL	Inconsistent	Regular	Low	0.99
GULL	Inconsistent	Regular	Low	1
HOOCH	Inconsistent	Regular	Low	1
HOOT	Inconsistent	Regular	Low	1
JAUNT	Inconsistent	Regular	Low	1
MOWN	Inconsistent	Regular	Low	1
PASTE	Inconsistent	Regular	Low	1
PERK	Inconsistent	Regular	Low	0.77
RAMP	Inconsistent	Regular	Low	1
ROVE	Inconsistent	Regular	Low	1
SCOUR	Inconsistent	Regular	Low	0.92
SLOUCH	Inconsistent	Regular	Low	0.92
STOW	Inconsistent	Regular	Low	1
TOAD	Inconsistent	Regular	Low	1
YARN	Inconsistent	Regular	Low	0.54
BULL	Inconsistent	Irregular	High	0.72
COME	Inconsistent	Irregular	High	0.69
COUGH	Inconsistent	Irregular	High	0.63
DREAD	Inconsistent	Irregular	High	0.88
DWARF	Inconsistent	Irregular	High	0.81
FOUR	Inconsistent	Irregular	High	0.7
GIVE	Inconsistent	Irregular	High	0.87

Word	Body	Regularity	Frequency	Probability Score
HARD	Inconsistent	Irregular	High	0.79
HORSE	Inconsistent	Irregular	High	0.76
LOVE	Inconsistent	Irregular	High	0.7
SOUP	Inconsistent	Irregular	High	0.7
STEAK	Inconsistent	Irregular	High	0.76
SWORD	Inconsistent	Irregular	High	0.81
TOMB	Inconsistent	Irregular	High	0.67
WEAR	Inconsistent	Irregular	High	0.84
WHERE	Inconsistent	Irregular	High	1
WHO	Inconsistent	Irregular	High	0.1
DEARTH	Inconsistent	Irregular	Low	1
DROWN	Inconsistent	Irregular	Low	0.99
GASP	Inconsistent	Irregular	Low	0.79
HEWN	Inconsistent	Irregular	Low	0.75
SHONE	Inconsistent	Irregular	Low	0.69
SOOT	Inconsistent	Irregular	Low	0.89
TON	Inconsistent	Irregular	Low	0.95
WOW	Inconsistent	Irregular	Low	0.98
BULB	Unique	Regular	High	1
DEBT	Unique	Regular	High	1
DESK	Unique	Regular	High	1
DOUBT	Unique	Regular	High	0.89
FILM	Unique	Regular	High	1
GULF	Unique	Regular	High	1
PEACE	Unique	Regular	High	0.77
SAUCE	Unique	Regular	High	1
SIGN	Unique	Regular	High	0.7
SOAP	Unique	Regular	High	1
STYLE	Unique	Regular	High	1

Word	Body	Regularity	Frequency	Probability Score
TYPE	Unique	Regular	High	1
VEIL	Unique	Regular	High	0.93
WAIST	Unique	Regular	High	1
BURNT	Unique	Regular	Low	1
CHIRP	Unique	Regular	Low	0.76
CLOTHE	Unique	Regular	Low	0.84
CUSP	Unique	Regular	Low	1
DUCT	Unique	Regular	Low	1
FUGUE	Unique	Regular	Low	0.89
FURZE	Unique	Regular	Low	0.8
GAUZE	Unique	Regular	Low	1
KILN	Unique	Regular	Low	1
KNOSP	Unique	Regular	Low	1
LEASH	Unique	Regular	Low	1
LOATHE	Unique	Regular	Low	0.79
MOSQUE	Unique	Regular	Low	0.79
NOUN	Unique	Regular	Low	0.89
PHLEGM	Unique	Regular	Low	1
TWERP	Unique	Regular	Low	0.92
ZINC	Unique	Regular	Low	1
AISLE	Unique	Irregular	High	0.53
COURT	Unique	Irregular	High	0.77
CURVE	Unique	Irregular	High	0.78
EYE	Unique	Irregular	High	0.46
GAOL	Unique	Irregular	High	0
HEART	Unique	Irregular	High	0.77
MYRRH	Unique	Irregular	High	0
PRIEST	Unique	Irregular	High	1
QUEUE	Unique	Irregular	High	0.57

Word	Body	Regularity	Frequency	Probability Score
SEARCH	Unique	Irregular	High	0.77
TONGUE	Unique	Irregular	High	0.95
YOUNG	Unique	Irregular	High	0.68
BILGE	Unique	Irregular	Low	0.89
BUOY	Unique	Irregular	Low	1
DRACHM	Unique	Irregular	Low	0
GAUCHE	Unique	Irregular	Low	0.44
HEARSE	Unique	Irregular	Low	0.91
NEWT	Unique	Irregular	Low	1
SUEDE	Unique	Irregular	Low	0
YACHT	Unique	Irregular	Low	0.39

PSEUDOWORD STIMULI

Word	Body
BINK	Consistent
BUEL	Consistent
CHAKE	Consistent
CLORT	Consistent
COUT	Consistent
CRANCE	Consistent
CRILL	Consistent
DIST	Consistent
DOAST	Consistent
FARK	Consistent
FORN	Consistent
FREDGE	Consistent
FRICK	Consistent
FRIECE	Consistent
FULP	Consistent
GACT	Consistent
GUG	Consistent
JIGHT	Consistent
KNEND	Consistent
LAIL	Consistent
LESH	Consistent
LIRL	Consistent
LURN	Consistent
MECK	Consistent
MEPT	Consistent
NAIN	Consistent
NALM	Consistent
NARGE	Consistent

Word	Body
NEIGN	Consistent
NIQUE	Consistent
PLAW	Consistent
POAT	Consistent
QUEE	Consistent
RELT	Consistent
RENE	Consistent
SHENT	Consistent
SICE	Consistent
SKILE	Consistent
SLOAX	Consistent
SLURE	Consistent
SNATE	Consistent
TADE	Consistent
THIT	Consistent
TRINCH	Consistent
TUILT	Consistent
TWIFF	Consistent
WHOB	Consistent
WURN	Consistent
XANG	Consistent
ZUB	Consistent
BROSS	Inconsistent
CEARTH	Inconsistent
CORSE	Inconsistent
DINTH	Inconsistent
FARN	Inconsistent
FINT	Inconsistent
FOUP	Inconsistent
GAND	Inconsistent

Word	**Body**
GASTE	Inconsistent
GEAF	Inconsistent
GIMB	Inconsistent
GOOTH	Inconsistent
GOUCH	Inconsistent
HARCE	Inconsistent
KUISE	Inconsistent
LERK	Inconsistent
LOLF	Inconsistent
LORSE	Inconsistent
MURY	Inconsistent
NAR	Inconsistent
NERK	Inconsistent
NOWL	Inconsistent
PANGE	Inconsistent
PAUNT	Inconsistent
PLARE	Inconsistent
PLEW	Inconsistent
RILD	Inconsistent
SARD	Inconsistent
SLASP	Inconsistent
SLEIR	Inconsistent
SMARCE	Inconsistent
SOOCH	Inconsistent
SOOL	Inconsistent
SUGE	Inconsistent
SWARF	Inconsistent
TEWN	Inconsistent
THAVE	Inconsistent
TIEVE	Inconsistent

Word	Body
TORM	Inconsistent
TREAST	Inconsistent
TUIT	Inconsistent
TWAMP	Inconsistent
TWORD	Inconsistent
BOVE	Inconsistent
CHON	Inconsistent
CHONE	Inconsistent
DEAK	Inconsistent
FO	Inconsistent
FOW	Inconsistent
GOOT	Inconsistent
GOUGH	Inconsistent
KEAD	Inconsistent
KIVE	Inconsistent
LOUR	Inconsistent
MOMB	Inconsistent
MOUGH	Inconsistent
NAS	Inconsistent
ROWN	Inconsistent
SLEAR	Inconsistent
SNULL	Inconsistent
SOST	Inconsistent
WOME	Inconsistent
ZEAT	Inconsistent
ZERE	Inconsistent
BACHT	Unique
BEUE	Unique
BIGN	Unique
BLAOL	Unique

Word	Body
BRACHM	Unique
CHEBT	Unique
COUN	Unique
CYLE	Unique
DILGE	Unique
DOSQUE	Unique
FAUCE	Unique
FAUZE	Unique
FEGM	Unique
FOUBT	Unique
FOUNG	Unique
FUEDE	Unique
GEASH	Unique
GERP	Unique
GOAP	Unique
GURNT	Unique
GURVE	Unique
GUSP	Unique
HOTHE	Unique
JIRP	Unique
KEACE	Unique
KULF	Unique
LEART	Unique
LOURT	Unique
MAUCHE	Unique
MOATHE	Unique
NAIST	Unique
NIEST	Unique
NONGUE	Unique
NUGUE	Unique

Word	Body
NYRRH	Unique
PILM	Unique
PLINC	Unique
PUOY	Unique
REARCH	Unique
RUCT	Unique
SAISLE	Unique
SEARSE	Unique
SILN	Unique
SLEIL	Unique
SURVE	Unique
SYPE	Unique
TESK	Unique
TURZE	Unique

PSEUDOHOMOPHONE STIMULI

Word	**Homophonic Pronunciation**	**Body**
BENE	Been	Consistent
CIRL	Curl	Consistent
FOAX	Folks	Consistent
GEIGN	Gain	Consistent
GILE	Gyle	Consistent
GRIECE	Greece	Consistent
MIQUE	Meek	Consistent
NOAT	Note	Consistent
PADE	Paid	Consistent
POAST	Post	Consistent
PUEL	Pool	Consistent
RECK	Wreck	Consistent
RIST	Wrist	Consistent
SKAIL	Scale	Consistent
BEWN	Bone	Inconsistent
BOAD	Bode	Inconsistent
BOUL	Bowl	Inconsistent
BRURY	Brewery	Inconsistent
CEAR	Care	Inconsistent
CHEAF	Chief	Inconsistent
CLEW	Clue	Inconsistent
CLIEVE	Cleave	Inconsistent
FEAK	Fake	Inconsistent
FOME	Foam	Inconsistent
FONE	Phone	Inconsistent
GEAT	Gate	Inconsistent
GEIR	Gear	Inconsistent

Word	Homophonic Pronunciation	Body
GEW	Goo	Inconsistent
GIEVE	Give	Inconsistent
GLOUR	Glower	Inconsistent
GOME	Gum	Inconsistent
GOOL	Ghoul	Inconsistent
GOST	Ghost	Inconsistent
GOW	Go	Inconsistent
GRIMB	Grime	Inconsistent
GROMB	Groom	Inconsistent
HOMB	Home	Inconsistent
HOUCH	Hutch	Inconsistent
JEAR	Jeer	Inconsistent
KAND	Canned	Inconsistent
LASTE	Last	Inconsistent
LEAT	Late	Inconsistent
LEIGHT	Late	Inconsistent
LEIR	Leer	Inconsistent
LERE	Lair	Inconsistent
LOWN	Loan	Inconsistent
MEIGHT	Might	Inconsistent
MOWL	Mole	Inconsistent
MUIT	Mute	Inconsistent
NEAD	Need	Inconsistent
NERE	Near	Inconsistent
NEWN	Known	Inconsistent
NOWN	Noun	Inconsistent
POOT	Put	Inconsistent
PORSE	Purse	Inconsistent
PREAST	Priest	Inconsistent

Word	Homophonic Pronunciation	Body
REAK	Reek	Inconsistent
ROUR	Roar	Inconsistent
SERE	Sear	Inconsistent
SHEAT	Sheet	Inconsistent
SIVE	Sieve	Inconsistent
SNOUP	Snoop	Inconsistent
SNUISE	Snooze	Inconsistent
SORD	Sword	Inconsistent
SOUGH	Sew	Inconsistent
TOWL	Towel	Inconsistent
WURY	Worry	Inconsistent
BAOL	Bale	Unique
BRINC	Brink	Unique
BUCT	Bucked	Unique
FAISLE	File	Unique
FLEGM	Phlegm	Unique
FLOUBT	Flout	Unique
FYLE	File	Unique
FYRRH	Fur	Unique
GEYE	Guy	Unique
GOUN	Gown	Unique
HACHM	Ham	Unique
HACHT	Hot	Unique
LEBT	Let	Unique
MEIL	Male	Unique
MIGN	Mine	Unique
NEACE	Niece	Unique
NEUE	New	Unique
PAIST	Paste	Unique

Word	Homophonic Pronunciation	Body
PAUZE	Pause	Unique
PEARCH	Perch	Unique
POAP	Pope	Unique
REWT	Route	Unique
ROUNG	Rung	Unique
SNYPE	Snipe	Unique
SOURT	Sort	Unique
STEART	Start	Unique
WOSP	Wasp	Unique
WUEDE	Wade	Unique
YIEST	Yeast	Unique
YONGUE	Young	Unique

"STRANGE" PSEUDOWORD STIMULI

BYAECK	SCHMYHR
COEW	SCHNAELDST
CZEURV	SCREARG
DHEWM	SEID
DIJIWST	SHEERTS
DUAST	SHEOCH
FRIONT	SHHULPT
GEUP	SPHOARRS
GHUISACH	SPLEIJ
GRYK	SPROUV
KHAURRH	THWAONST
KNYL	TOOND
KROENGST	WHUIM
KVOUCHMS	WOILL
LOAY	YAUTH
MYENG	ZEILTH
NUELD	
PAOBY	
PHAIKH	
PHLIOHM	
PHRITSCH	
PLAAS	
PSUAVS	
PTAAMF	
RHADZ	
RUPGHT	

APPENDIX TWO

LEXICAL DECISION STIMULI

LD1	LD2	LD3	LD4
bury	mury	fury	wury
sew	brew	plew	clew
gaste	laste	paste	caste
wand	gand	kand	gland
geaf	leaf	deaf	cheaf
sword	sord	tword	word
doad	toad	boad	broad
tuit	suit	quit	muit
bead	kead	dread	nead
steak	bleak	feak	deak
jear	wear	dear	slear
tomb	momb	bomb	gromb
mown	lown	rown	drown
leart	steart	heart	
fint	mint	pint	
farce	smarce	scarce	
doast	poast	coast	
chon	ton	con	
faisle	saisle	aisle	
myrrh	fyrrh	nyrrh	
foung	young	roung	
drachm	hachm	brachm	
swarf	dwarf	scarf	
zinc	plinc	brinc	

LD1	LD2	LD3	LD4
wuede	fuede	suede	
lail	rail	skail	
niece	griece	friece	
plaw	gnaw		
nugue	fugue		
slate	snate		
fulp	gulp		
fact	gact		
soap	poap		
searse		hearse	
grit		thit	

APPENDIX THREE

READING FOR MEANING STIMULI

aisle	*a passageway*	a vehicle (car) a utensil (spoon)
aunt	*your mother's sister*	your child's toy (teddy) your dog's home (kennel)
barge	*a boat for carrying cargo*	a machine for harvesting grain (combine) a vehicle for collecting rubbish (bin lorry)
bead	*a part of a necklace*	a piece of footwear (shoe) a type of fruit (apple)
bilge	*the water from a boat*	the liquid from an olive (oil) the smell from an animal (scent)
bleak	*uninspiring*	sweltering (hot) charming (attractive)
blight	*a disease*	a song (hymn) a container (basket)
boat	*a floating vessel*	a fighting weapon (sword) a cooking utensil (spoon)
bomb	*an explosive device*	an eligible man (bachelor) a finance house (bank)
bough	*a tree branch*	a dog house (kennel) a doorknob (handle)
bowl	*a dish*	a lamp (light) a chute (slide)
breast	*chest*	toilet (lavatory) heater (radiator)

brew	*to boil*	to fight (brawl) to question (query)
broad	*wide*	beautiful (pretty) quick (fast)
brooch	*a piece of jewellery*	a type of sweet (toffee) a sort of insect (bee)
bruise	*a mark on the skin*	a light in the sky (star) a picture of a country (map)
bug	*an insect*	a drink (juice) a tool (spanner)
bulb	*a plant seed*	a church bench (pew) a rubbish store (dustbin)
bull	*a male cow*	a long stick (pole) a fast car (BMW)
buoy	*a marker used at sea*	a tool used for gardening (spade) a container used for storage (bottle)
burnt	*damaged by heat*	stitched with thread (sewn) removed by thieves (stolen)
bury	*to put under the ground*	to play cards for money (gamble) to travel over water (sail)
caste	*a level in Indian society*	a type of dessert (mousse) a fluid in the body (blood)
chirp	*a bird noise*	a drink container (bottle) a grain store (barn)
clerk	*a person who works in an office*	a container which holds liquid (tank) a chilled cabinet for food (fridge)
climb	*to go upwards*	to shove through (push) to go under (sink)
clique	*an exclusive group*	a pleasant smell (perfume) a difficult decision (dilemma)

clothe	*to dress*	to jump (leap) to plant (sow)
coast	*where land and sea meet*	where actors and actresses perform (stage) where flowers and plants grow (garden)
comb	*a hair implement*	a money holder (purse) a floor covering (carpet)
come	*to arrive*	to dress (clothe) to soak (steep)
con	*to cheat*	to destroy (ruin) to love (adore)
corn	*a grain*	a colour (yellow) a country (France)
cost	*the price of something*	the form of something (shape) the heaviness of something (weight)
cough	*to clear the throat*	to jump up and down (leap) to chase an animal (hunt)
coup	*a take-over*	a dance step (tango) a bottle opener (corkscrew)
court	*a building for legal proceedings*	an animal for load bearing (donkey) an implement for writing (pen)
cross	*angry*	pretty (beautiful) wealthy (rich)
curve	*an arc*	a jewel (opal) a picture (painting)
cusp	*a curved border*	a rough road (track) a writing implement (pen)
dance	*to move to music*	to plunge into water (dive) to take a picture (photograph)
deaf	*unable to hear*	unable to read (illiterate) unable to bend (rigid)

dear	*expensive*	abusive (rude) obvious (clear)
dearth	*a lack (of something)*	a block of wood (plank) a group of people (crowd)
debt	*money owed to another*	thoughts during sleep (dreams) uncertainty about something (doubt)
desk	*a writing table*	a digging implement (spade) a travelling bag (suitcase)
dive	*to go headfirst into water*	to go up a high mountain (climb) to stop working in protest (strike)
dome	*a rounded roof*	a gifted person (genius) a prickly plant (cactus)
doubt	*to be unsure*	to destroy (ruin) to scratch (scrape)
dough	*uncooked bread*	natural light (sunshine) wood shavings (sawdust)
drachm	*a unit of measurement*	a part of a bicycle (handlebar) a type of insect (mosquito)
dread	*to fear*	to shout (yell) to observe (watch)
drown	*to die in water*	to smell nasty (pong) to go up hill (climb)
duct	*a channel*	a light (lamp) a tale (story)
duel	*a fight between two people*	a type of foreign food (Sushi) a bag for holding money (purse)
dwarf	*a very small person*	a milk producing animal (cow) a heavy snow-storm (blizzard)
eye	*an organ for sight*	an animal for riding (horse) a cloth for cleaning (duster)

fact	*something truthful*	something edible (cake) something wearable (dress)
farce	*a comedy*	a vehicle (van) a utensil (fork)
feast	*a banquet*	a machine (vacuum cleaner) a book (novel)
film	*a cinema show*	a long walk (hike) a bottle opener (corkscrew)
flange	*a projecting rim*	a flightless bird (penguin) a blending machine (mixer)
fool	*an idiot*	a frock (dress) a bowl (dish)
form	*a shape*	a scent (odour) a texture (rough)
four	*the number between three and five*	the month between January and March (February) a place between Glasgow & Edinburgh (Bathgate)
free	*not costing anything*	not moving at all (stationary) not very common (rare)
fugue	*a musical term*	a natural fuel (coal) a synthetic fabric (nylon)
fury	*anger*	warmth (friendliness) irony (sarcasm)
furze	*a type of undergrowth*	a variety of vegetable (parsnip) a kind of sweet (toffee)
gang	*a group of people*	a place for rubbish (dump) a mass of trees (forest)
gaol	*a prison*	a feather (quill) a shrub (bush)

gas	*a fuel*	a virtue (patience) a drink (water)
gasp	*to breathe quickly*	to speak loudly (shout) to divide evenly (share)
gauche	*clumsy*	cross (angry) talkative (chatty)
gauze	*a first aid material*	a make of car (Vauxhall) a hot drink (tea)
gave	*donated*	imbibed (drank) damaged (broke)
gild	*to cover with gold*	to construct with bricks (build) to brush with oil (baste)
girl	*a young female child*	a huge ugly monster (giant) a pretty winged insect (butterfly)
gist	*essence*	value (cost) weight (heaviness)
give	*to donate*	to illustrate (draw) to glow (shine)
gland	*a part of the body*	a type of apple (cox) a scrap of cloth (remnant)
gnaw	*to chew*	to shout (yell) to leap (jump)
go	*to move forward*	to tip over (spill) to give in (yield)
golf	*a sport*	a fuel (gas) a poison (cyanide)
grange	*a large house*	a cuddly toy (teddy) a wild cat (tiger)
great	*very large*	very ugly (gross) totally full (stuffed)

grieve	*to mourn*	to purchase (buy) to spoil (ruin)
grit	*small stones*	frozen water (ice) fermented milk (yoghurt)
gross	*144*	20 (score) 12 (dozen)
growl	*a dog's threatening noise*	a child's soft toy (teddy) a soldier's official clothing (uniform)
guise	*not as it seems*	not ready on time (late) not very warm (cool)
gulf	*a big gap*	a pink flower (carnation) a young sheep (lamb)
gull	*a sea bird*	an explosive device (bomb) a woolly jumper (jersey)
gulp	*to swallow quickly*	to fight fiercely (battle) to laugh heartily (chuckle)
hard	*not soft*	not old (young) not hot (cold)
has	*possesses*	cleanses (washes) wants (craves)
have	*to own*	to munch (eat) to yank (pull)
hearse	*a funeral car*	a leafy plant (yukka) a poor person (pauper)
heart	*an organ pumping blood around the body*	a gas appliance which heats water (boiler) a place which lends books (library)
hearth	*a fireside*	a gentle wind (breeze) a tank (aquarium)
height	*a vertical measurement*	a type of drink (milk) a bright colour (orange)

heir	*an inheritor*	an assailant (attacker) a physician (doctor)
here	*in this place*	not long ago (recently) as a result of (consequently)
hewn	*carved*	stewed (casseroled) dyed (coloured)
hoax	*a trick*	a cooker (an oven) a chair (seat)
hooch	*illegal alcohol*	unleavened bread (pitta) topical information (news)
hoot	*the noise made by an owl*	the house owned by a king (castle) the object created by a potter (vase)
horse	*a four-legged animal*	a very large hill (mountain) a precious stone (gem)
huge	*very large*	very clean (spotless) very inexpensive (cheap)
jar	*a glass container*	a long journey (trek) a poor person (pauper)
jaunt	*an outing*	an insect (bee) a plant (rose)
kiln	*an oven*	a jumper (sweater) a germ (bacterium)
knelt	*went down on their knees*	moved through water (swam) went up a hill (climbed)
knob	*a door handle*	a cutting tool (knife) a walking stick (staff)
knosp	*a ceiling rose*	a male horse (stallion) a moral story (fable)
lark	*a bird*	a vehicle (lorry) a plant (poppy)

leaf	*a part of a tree*	a type of animal (cat) the bottom of a shoe (sole)
leash	*a lead for a dog*	a cover for a record (sleeve) a container for a drink (glass)
limb	*an arm*	a bottle (container) a spade (tool)
loathe	*to hate*	to chuckle (laugh) to be sick (vomit)
lough	*an Irish lake*	a fierce animal (lion) a small flower (daisy)
love	*to adore*	to bear (carry) to manage (cope)
luge	*a sledge*	a vegetable (carrot) an animal (monkey)
mesh	*netting*	washing (laundry) baking (cakes)
mild	*gentle*	loud (noisy) vacant (empty)
mile	*a measure of distance*	a time of year (season) a degree of colour (shade)
milk	*the liquid from a cow*	the skin from a fruit (peel) the product of a bakery (bread)
mill	*a place where corn is ground*	a field where rugby is played (pitch) a place where books are stored (library)
mint	*a herb*	a sport (skiing) an illness ('flu)
mosque	*a Muslim place of worship*	a type of car (Rover) a gadget for taking photos (camera)
mown	*to have cut the grass*	to have bought the groceries (shopped) to have shut the door (closed)

myrrh	*a gift of the three wise men*	the innards of a cow (offal) the fuel for a car (petrol)
neck	*body part joining the head and shoulders*	a machine orbiting the sun and planets (satellite) person opposing the Conservatives and Labour (Liberal)
newt	*a pond creature*	a soft fruit (plum) a yellow flower (daffodil)
niece	*a brother's daughter*	a cat's offspring (kitten) an artist's work (painting)
ninth	*the position between eighth and tenth*	the country between Portugal and France (Spain) the season between summer and winter (autumn)
noun	*a naming word*	a birthday celebration (party) a kitchen utensil (knife)
paste	*a mixture of powder and water*	a mixture of meat and vegetables (stew) a group of cows and bulls (herd)
peace	*a state of calm*	a belief in something (faith) a feeling of shyness (embarrassment)
perk	*a benefit*	a dress (frock) an answer (solution)
phlegm	*the product of a cough*	the liquid from a fruit (juice) the fumes from a fire (smoke)
pinch	*to nip*	to jump (leap) to yell (shout)
pint	*a measurement of liquid*	a group of animals (herd) a string of words (sentence)
plinth	*a platform for display*	a utensil for baking (spatula) a container for storage (bottle)

post	*to send by mail*	to learn by heart (memorise) to sort by type (categorise)
priest	*a religious leader*	a yellow bird (canary) a large hill (mountain)
psalm	*a religious song*	a competitive event (match) a large dog (Great Dane)
queue	*a line of people waiting*	a herd of cattle running (stampede) a group of people singing (choir)
quick	*fast*	awkward (clumsy) little (small)
quilt	*a bedcover*	a vegetable (cauliflower) a container (tub)
quit	*to leave*	to weep (cry) to battle (fight)
rail	*a train track*	a storage place (cupboard) a safe place (haven)
ramp	*a slope in the road*	a table in the office (desk) a light in the sky (star)
reign	*to rule*	to throw (chuck) to yell (shout)
rove	*to wander*	to yell (shout) to push (shove)
rub	*to stroke vigorously*	to speak loudly (shout) to walk quickly (run)
sauce	*a liquid poured over food*	a rocket-launched weapon (bomb) a cavity in the earth (crater)
scarce	*rare*	organised (efficient) perfect (flawless)
scarf	*clothing for the neck*	a port for ships (harbour) a store for furniture (warehouse)

scene	*a part of a play*	a piece of a cake (slice) an area of grass (lawn)
scent	*a smell*	an animal (tiger) a utensil (knife)
scour	*to scrub clean*	to make biscuits (bake) to fall over (slip)
search	*to look for*	to write music (compose) to spread about (scatter)
sew	*to join together using needle and thread*	to heat water until bubbling (boil) to slice finely with a knife (chop)
sewn	*stitched with needle and thread*	drawn with brushes and paints (painted) cleaned with soap and water (washed)
share	*to divide among*	to pass over (ignore) to put aside (discard)
shone	*what the sun did in summer*	what the minister did on Sunday (preached) what the chef did at work (cooked)
sieve	*a straining utensil*	a running shoe (trainer) a hunting animal (dog)
sign	*an omen*	an opening (entrance) an animal (badger)
sign	*an omen*	an opening (entrance) an animal (mammal)
sink	*to go under water*	to move forward (walk) to plant seeds (sown)
slain	*killed*	cleaned (washed) sewn (stitched)
slate	*a stone for roof tiles*	an outdoor game (cricket) a type of seaweed (kelp)
slouch	*to slump*	to jump (leap) to fight (battle)

smooth	*even*	witty (funny) peaceful (calm)
soap	*a substance used for washing*	a liquid used for cooking (oil) a material used for drawing (paint)
soot	*black powder from coal*	milky liquid from plants (sap) sweet substance from cocoa (chocolate)
sort	*to categorise*	to destroy (ravage) to annoy (irritate)
soup	*a liquid food*	a winter sport (skiing) a floor covering (carpet)
spade	*a digging implement*	a writing tool (pen) a counting machine (calculator)
spend	*to pay money for goods*	to ask for something (request) to separate with scissors (cut)
steak	*a piece of beef*	a place to swim (pool) a tall building (skyscraper)
stiff	*rigid*	ripped (torn) omitted (forgotten)
stow	*to store away*	to move rhythmically (dance) to hit softly (pat)
style	*a way of doing something*	a great love for something (passion) a mental picture of something (image)
suede	*a type of leather*	a source of heat (gas) a type of sweet (fudge)
suit	*matching clothes*	underground transport (tube) window covering (curtain)
sure	*certain*	sophisticated (suave) illegal (illicit)
swamp	*marshy ground*	floor covering (carpet) lumpy soup (potage)

sweat	*to perspire*	to trap (catch) to develop (grow)
sword	*a fighting weapon*	a flying machine (plane) an instrumental group (orchestra)
take	*to remove from*	to move through water (swim) to get warm (heat)
toad	*an animal like a frog*	a fruit like a peach (nectarine) an insect like a butterfly (moth)
tomb	*a grave*	a biscuit (digestive) a story (tale)
ton	*a measure of weight*	group of sheep (flock) a source of light (candle)
tone	*a musical sound*	an unpleasant smell (odour) a valuable stone (gem)
tooth	*a thing in the mouth*	a part of a television (screen) a type of animal (fox)
touch	*to feel*	to chat (talk) to sprint (run)
treat	*a reward*	a smell (scent) a marsh (swamp)
trout	*a fish*	a fruit (banana) a drink (coffee)
turn	*to rotate*	to plait (pleat) to close (shut)
twerp	*an idiot*	a bowl (dish) a moped (scooter)
veil	*a face-covering*	a wooden bench (form) a small rodent (mouse)
waist	*middle part of the body*	meal before bedtime (supper) side of the road (kerb)

wand	*a stick with magic powers*	a tool with many blades (penknife) a shoe with a high heel (stiletto)
war	*a fight between two countries*	a platform on a stage (podium) a passage under water (tunnel)
ward	*a hospital room*	a cardboard carton (box) a sailing vessel (boat)
warn	*to indicate danger*	to evaluate ability (assess) to hold close (hug)
was	*used to be*	used to have (had) used to drink (drank)
wasp	*a stinging insect*	a healing drug (medicine) a fiction book (novel)
wear	*to put on clothes*	to wash thoroughly (cleanse) to light a fire (ignite)
wedge	*a piece of wood*	a part of a car (wheel) a cutting tool (knife)
weight	*a measure of heaviness*	a sort of car (Volvo) a state of chaos (pandemonium)
weir	*a waterfall*	a building (house) a fruit (banana)
wept	*cried*	enjoyed (liked) washed (cleaned)
where?	*which place?*	which time? (when?) which reason? (why?)
who?	*which person?*	which object? (what?) which place? (where?)
wolf	*a wild dog-like animal*	a piece of office furniture (desk) a part of a car (engine)
wool	*material from a sheep*	liquid from a fruit (juice) timber from a tree (wood)

word	*a string of letters*	a group of people (crowd) a row of houses (street)
worm	*a creature in the earth*	a piece of an orange (segment) a container for rubbish (bin)
worse	*not as good as before*	not as early as before (later) not as cold as before (warmer)
wow	*an exclamation of surprise*	a type of sport (running) an alcoholic drink (gin)
yacht	*a sailing boat*	a singing group (choir) a cattle shed (barn)
yarn	*thread*	dish (bowl) rubber (eraser)
young	*not old*	not happy (sad) not poor (rich)
zinc	*a metallic element*	a metric measure (kilo) a gastric juice (HCL)

APPENDIX FOUR

This appendix contains a listing of every stimulus which was read aloud incorrectly, the type of errors which were made and the participants who made them. Any incorrect productions that were real words are written in their standard English form, whilst incorrect productions that were not real words are presented in phonetic symbols. As in Appendix One, the stimuli are organised first by body neighbourhood and then, where applicable, by regularity and frequency.

In order that all the information could be included in the tables, it was necessary to abbreviate some of the classifications so a key has been included below.

Key to abbreviations:

B = Body Neighbourhood	R = Regularity	F = Frequency
C = consistent	R = regular	H = high
E = exception	I = irregular	L = low
I = inconsistent		
U = unique		

REAL WORD ERRORS

Target	Production	Error Type	Participant	B	R	F
BOAT	boats	derivational	7	C	R	H
COAST	coasts	derivational	7	C	R	H
CORN	earn	visual	13	C	R	H
FREE	flee	visual	14	C	R	H
GANG	no response		7	C	R	H
GANG	[gɑm]	phonological	10	C	R	H
MILE	smile	visual	8	C	R	H
MILE	[mɪr]	neologism	10	C	R	H
MILL	milk	visual	7	C	R	H
MILL	[maɪlə]	neologism	10	C	R	H
REIGN	[rɪnə]	neologism	10	C	R	H
REIGN	ranging	mde	13	C	R	H
SCENT	[ʃɛnt]	derivational	7	C	R	H
SCENT	sense	mde	14	C	R	H
SORT	short	visual	7	C	R	H
SORT	sure	initial letter	10	C	R	H
SORT	soft	visual	13	C	R	H
SORT	soft	visual	14	C	R	H
SPEND	[spɛld]	phonological	10	C	R	H
SPEND	speech	visual	14	C	R	H
TAKE	talk	visual	10	C	R	H
TROUT	trot	visual	13	C	R	H
BUG	bugs	derivational	7	C	R	L
BUG	bum	visual	10	C	R	L
BUG	huge	mde	13	C	R	L

Target	Production	Error Type	Participant	B	R	F
BUG	bud	visual	14	C	R	L
GIST	[gɪst]	phonological	2	C	R	L
GIST	[gɪst]	phonological	3	C	R	L
GIST	[gɪst]	phonological	5	C	R	L
GIST	[gɛlə]	neologism	10	C	R	L
GIST	no response		12	C	R	L
GIST	gilt	visual	13	C	R	L
GNAW	[gɔ]	phonological	1	C	R	L
GNAW	[gnɔ]	phonological	3	C	R	L
GNAW	no response		10	C	R	L
GNAW	Graham	initial letter	13	C	R	L
GRIT	[grɑt]	phonological	10	C	R	L
GRIT	guide	initial letter	13	C	R	L
GRIT	good	initial letter	14	C	R	L
GULP	[gɪlp]	phonological	1	C	R	L
GULP	guilt	initial letter	10	C	R	L
GULP	no response		13	C	R	L
HOAX	hawick	initial letter	7	C	R	L
HOAX	[həksə]	phonological	10	C	R	L
KNELT	[knɛlt]	phonological	6	C	R	L
KNELT	kneel	derivational	10	C	R	L
KNELT	kneel	derivational	13	C	R	L
KNELT	kneel	derivational	14	C	R	L
KNOB	[nɒbi]	phonological	1	C	R	L
KNOB	[nɒbə]	phonological	10	C	R	L
LARK	hark	visual	7	C	R	L
MESH	no response		7	C	R	L

Target	Production	Error Type	Participant	B	R	F
MESH	[mɛsl]	neologism	10	C	R	L
MESH	no response		13	C	R	L
NIECE	nice	visual	1	C	R	L
NIECE	nice	visual	14	C	R	L
PINCH	plinth	initial letter	11	C	R	L
PINCH	no response		13	C	R	L
PSALM	[pfɑm]	neologism	7	C	R	L
PSALM	palm	visual	10	C	R	L
PSALM	hymns	semantic	12	C	R	L
PSALM	no response		13	C	R	L
PSALM	palm	visual	14	C	R	L
QUILT	[kwʌlt]	phonological	1	C	R	L
QUILT	guilt	visual	5	C	R	L
QUILT	[kwɪlk]	phonological	10	C	R	L
QUILT	quick	visual	14	C	R	L
SLATE	slant	visual	10	C	R	L
SPADE	[biə]	neologism	1	C	R	L
SPADE	[sprɪdə]	neologism	10	C	R	L
WEPT	[swɛp]	neologism	7	C	R	L
WEPT	[wɛp]	phonological	10	C	R	L
WEPT	weep	derivational	13	C	R	L
WEPT	weep	derivational	14	C	R	L
SCENE	soon	initial letter	7	C	I	H
SURE	sore	visual	7	C	I	H
BARGE	[bɑrz]	phonological	7	C	I	L
BARGE	no response		13	C	I	L
BLIGHT	bright	visual	3	C	I	L
BLIGHT	bright	visual	5	C	I	L

Target	Production	Error Type	Participant	B	R	F
BLIGHT	blythe	mde	12	C	I	L
BLIGHT	brighter	mde	13	C	I	L
BLIGHT	bright	visual	14	C	I	L
CLIQUE	chain	initial letter	7	C	I	L
CLIQUE	[slandʒ]	neologism	10	C	I	L
CLIQUE	no response		13	C	I	L
CLIQUE	kill	unrelated	14	C	I	L
SLAIN	slaying	derivational	2	C	I	L
SLAIN	pale	unrelated	13	C	I	L
SLAIN	slim	initial letter	14	C	I	L
WEDGE	[rɛdʒ]	neologism	7	C	I	L
WEDGE	no response		10	C	I	L
BOMB	tomb	visual	8	E	R	H
CLIMB	[tibə]	neologism	1	E	R	H
CLIMB	[klɪmbɪf]	neologism	10	E	R	H
GILD	glisten	visual	2	E	R	H
GILD	[gʌlə]	neologism	10	E	R	H
GILD	glide	mde	11	E	R	H
GILD	gull	initial letter	12	E	R	H
GILD	no response		13	E	R	H
GILD	[gɪnə]	neologism	14	E	R	H
GOLF	[gɪlf]	phonological	1	E	R	H
HAS	had	derivational	2	E	R	H
HAS	lass	mde	7	E	R	H
HAS	yearn	unrelated	13	E	R	H
HUGE	shoes	phonological	7	E	R	H
HUGE	Hugh	visual	14	E	R	H
LIMB	limp	visual	10	E	R	H

Target	Production	Error Type	Participant	B	R	F
LIMB	tomb	visual	11	E	R	H
LIMB	limp	visual	13	E	R	H
LIMB	limp	visual	14	E	R	H
WAR	warm	visual	10	E	R	H
WAS	wasp	visual	7	E	R	H
WAS	whose	mde	10	E	R	H
WAS	[wɔz]	phonological	11	E	R	H
WORD	words	derivational	5	E	R	H
WORD	sword	visual	7	E	R	H
WORD	words	derivational	13	E	R	H
WORM	word	visual	10	E	R	H
WORSE	w.o.	letter-by-letter	12	E	R	H
WORSE	words	visual	13	E	R	H
WORSE	waste	initial letter	14	E	R	H
COMB	[kɒmb]	phonological	14	E	R	L
FARCE	first	initial letter	7	E	R	L
FARCE	farm	visual	10	E	R	L
FARCE	[frɛdʒ]	neologism	13	E	R	L
FARCE	force	visual	14	E	R	L
GUISE	[gɑz]	phonological	7	E	R	L
GUISE	grease	visual	10	E	R	L
GUISE	no response		13	E	R	L
NINTH	nine	mde	10	E	R	L
NINTH	plinth	visual	11	E	R	L
NINTH	mild	letter-by-letter	13	E	R	L
PLINTH	[plɪð]	neologism	5	E	R	L
PLINTH	[plɪmə]	neologism	10	E	R	L
PLINTH	no response		12	E	R	L
PLINTH	no response		13	E	R	L

Target	Production	Error Type	Participant	B	R	F
QUIT	[kɛtə]	neologism	1	E	R	L
QUIT	quick	visual	13	E	R	L
QUIT	quick	visual	14	E	R	L
SWAMP	[swəʊmə]	neologism	10	E	R	L
SWAMP	swarm	visual	13	E	R	L
SWAMP	swan	visual	14	E	R	L
WAND	wet	initial letter	7	E	R	L
WAND	warned	initial letter	9	E	R	L
WAND	no response		10	E	R	L
WAND	want	visual	11	E	R	L
WAND	weird	initial letter	13	E	R	L
WARN	warning	derivational	2	E	R	L
WARN	[warmbl]	neologism	10	E	R	L
WARN	warm	visual	13	E	R	L
WARN	waste	initial letter	14	E	R	L
WASP	wisp	phonological	9	E	R	L
WASP	[wɔsp]	phonological	13	E	R	L
WASP	waste	visual	14	E	R	L
WORM	worn	visual	13	E	R	L
ARE	no response		13	E	I	H
ARE	here	mde	14	E	I	H
AUNT	aunty	derivational	2	E	I	H
AUNT	aunty	derivational	14	E	I	H
BREAST	breasts	derivational	4	E	I	H
BREAST	no response		10	E	I	H
BREAST	beast	visual	14	E	I	H
BROAD	bread	visual	7	E	I	H
BROAD	bored	initial letter	13	E	I	H
COUP	cup	visual	1	E	I	H

Target	Production	Error Type	Participant	B	R	F
COUP	[kʌmrə]	neologism	10	E	I	H
COUP	cooper	mde	13	E	I	H
DEAF	dread	mde	10	E	I	H
DOUGH	Doug	visual	1	E	I	H
DOUGH	cough	visual	8	E	I	H
DOUGH	doughnut	mde	10	E	I	H
DOUGH	no response		13	E	I	H
HAVE	[hɪv]	phonological	1	E	I	H
HAVE	ramp	unrelated	7	E	I	H
HEIGHT	[nɪtə]	neologism	10	E	I	H
PINT	[pɛʊnt]	neologism	7	E	I	H
PINT	[pɪnt]	phonological	14	E	I	H
SCARCE	scared	visual	2	E	I	H
SCARCE	scare	visual	3	E	I	H
SCARCE	scare	visual	6	E	I	H
SCARCE	no response		7	E	I	H
SCARCE	scarf	visual	10	E	I	H
SCARCE	scary	visual	11	E	I	H
SCARCE	scared	visual	12	E	I	H
SCARCE	scare	neologism	13	E	I	H
SCARCE	scare	visual	14	E	I	H
SWEAT	meat	visual	7	E	I	H
SWEAT	sweater	derivational	10	E	I	H
SWEAT	swear	visual	11	E	I	H
SWEAT	no response		13	E	I	H
SWEAT	[swɪlf]	neologism	14	E	I	H
TOUCH	[tʌʃ]	phonological	7	E	I	H
TOUCH	[tʌts]	phonological	11	E	I	H

Target	Production	Error Type	Participant	B	R	F
WERE	where	visual	7	E	I	H
WERE	wear	visual	12	E	I	H
WERE	wear	initial letter	13	E	I	H
BROOCH	[brəʊs]	phonological	7	E	I	L
BROOCH	[brʊmʒ]	neologism	10	E	I	L
BROOCH	no response		11	E	I	L
BROOCH	[brʊmzɪ]	neologism	12	E	I	L
BROOCH	[bʊtʃəl]	neologism	14	E	I	L
BURY	buried	derivational	2	E	I	L
BURY	[bʌrnɛg]	neologism	10	E	I	L
BURY	buried	derivational	12	E	I	L
BURY	Barry	phonological	14	E	I	L
CASTE	castle	visual	2	E	I	L
CASTE	[karst]	phonological	10	E	I	L
CASTE	castle	visual	13	E	I	L
CASTE	cattle	initial letter	14	E	I	L
FLANGE	[flɑnz]	phonological	7	E	I	L
FLANGE	[flaɪndʒ]	phonological	8	E	I	L
FLANGE	flame	visual	10	E	I	L
FLANGE	no response		11	E	I	L
FLANGE	no response		13	E	I	L
FLANGE	[flɪm]	neologism	14	E	I	L
HEARTH	heart	visual	10	E	I	L
HEARTH	heart	visual	11	E	I	L
HEARTH	no response		13	E	I	L
HEARTH	health	visual	14	E	I	L
LOUGH	laugh	visual	13	E	I	L
LUGE	lunge	visual	6	E	I	L

Target	Production	Error Type	Participant	B	R	F
LUGE	lug	visual	7	E	I	L
LUGE	lug	visual	8	E	I	L
LUGE	lug	visual	9	E	I	L
LUGE	lunge	visual	10	E	I	L
LUGE	huge	visual	11	E	I	L
LUGE	no response		12	E	I	L
LUGE	no response		13	E	I	L
SEW	snow	mde	13	E	I	L
SEWN	sewing	derivational	2	E	I	L
SEWN	sew	derivational	6	E	I	L
SEWN	sewing	derivational	7	E	I	L
SEWN	sew	derivational	10	E	I	L
SEWN	sewing	derivational	12	E	I	L
SEWN	sew	derivational	14	E	I	L
SIEVE	sleeve	visual	14	E	I	L
WEIR	weird	visual	10	E	I	L
BLEAK	break	visual	5	I	R	H
BLEAK	[blɪtʃə]	neologism	10	I	R	H
BLEAK	no response		11	I	R	H
BLEAK	break	visual	13	I	R	H
BLEAK	bake	mde	14	I	R	H
COST	coast	visual	14	I	R	H
DOME	doom	initial letter	2	I	R	H
DOME	no response		7	I	R	H
DOME	[dʊmə]	neologism	10	I	R	H
FEAST	[fɪrd]	neologism	10	I	R	H
FEAST	no response		13	I	R	H
FOOL	foal	visual	13	I	R	H
FURY	furry	visual	1	I	R	H

Target	Production	Error Type	Participant	B	R	F
FURY	[frʊrə]	neologism	7	I	R	H
FURY	furry	visual	11	I	R	H
GAVE	grave	visual	7	I	R	H
GAVE	give	derivational	10	I	R	H
GAVE	grave	visual	12	I	R	H
GAVE	grieve	visual	13	I	R	H
GAVE	give	derivational	14	I	R	H
HEIR	hero	initial letter	2	I	R	H
HEIR	here	visual	10	I	R	H
JAR	jam	mde	10	I	R	H
MILD	mind	visual	5	I	R	H
MILD	no response		10	I	R	H
MINT	meet	initial letter	7	I	R	H
SHARE	sharp	visual	10	I	R	H
SUIT	suite	visual	9	I	R	H
SUIT	suite	visual	12	I	R	H
SUIT	suite	visual	14	I	R	H
TOMB	thumb	visual	14	I	R	H
TONE	note	mde	2	I	R	H
TONE	[tɔn]	phonological	10	I	R	H
TREAT	threat	visual	13	I	R	H
BEAD	bread	visual	7	I	R	L
BEAD	bread	visual	10	I	R	L
BEAD	bread	visual	11	I	R	L
BEAD	beach	visual	12	I	R	L
BEAD	bread	visual	13	I	R	L
BOUGH	bow	phonological	7	I	R	L
BOUGH	bow (low)	phonological	12	I	R	L
BOUGH	brought	mde	13	I	R	L

Target	Production	Error Type	Participant	B	R	F
BOUGH	[bɒf]	mde	14	I	R	L
BRUISE	braise	visual	1	I	R	L
BRUISE	no response	mde	5	I	R	L
BRUISE	[brʊtə]	neologism	10	I	R	L
BRUISE	[brɒsk]	neologism	11	I	R	L
CON	corn	visual	7	I	R	L
CON	come	visual	10	I	R	L
CON	come	visual	13	I	R	L
DIVE	drive	visual	13	I	R	L
DIVE	drive	visual	14	I	R	L
GLAND	no response		7	I	R	L
GLAND	[glɑmp]	phonological	10	I	R	L
GLAND	[glɑn]	phonological	12	I	R	L
GLAND	glance	visual	13	I	R	L
GRANGE	no response		7	I	R	L
GRANGE	grove	initial letter	10	I	R	L
GRANGE	grain	semantic	11	I	R	L
GRANGE	orange	visual	13	I	R	L
GRANGE	garage	mde	14	I	R	L
GROWL	[gɛli]	neologism	1	I	R	L
GROWL	[glaɪ]	neologism	8	I	R	L
GROWL	grovel	visual	10	I	R	L
GROWL	glow	mde	13	I	R	L
GULL	gill	visual	7	I	R	L
GULL	[glʌl]	phonological	8	I	R	L
GULL	jug	perseveration	13	I	R	L
HEIR	no response		11	I	R	L
HEIR	higher	initial letter	14	I	R	L

Target	Production	Error Type	Participant	B	R	F
HOOCH	[hʊç]	neologism	3	I	R	L
HOOCH	[hʊç]	phonological	4	I	R	L
HOOCH	shop	unrelated	7	I	R	L
HOOCH	brooch	visual	8	I	R	L
HOOCH	[hʊf]	phonological	10	I	R	L
HOOCH	no response		11	I	R	L
HOOCH	no response		13	I	R	L
HOOT	[gʊt]	phonological	10	I	R	L
HOOT	host	visual	13	I	R	L
HOOT	hoop	visual	14	I	R	L
JAUNT	gaunt	visual	5	I	R	L
JAUNT	jaunts	derivational	7	I	R	L
JAUNT	[dʒɔbəlrələ]	neologism	10	I	R	L
JAUNT	jauntily	derivational	12	I	R	L
JAUNT	no response		13	I	R	L
MOWN	mow	derivational	2	I	R	L
MOWN	mow	neologism	7	I	R	L
MOWN	mauve	initial letter	10	I	R	L
MOWN	mow	derivational	12	I	R	L
MOWN	frown	visual	13	I	R	L
PASTE	pasta	visual	10	I	R	L
PASTE	pastel	visual	11	I	R	L
PASTE	plastic	visual	12	I	R	L
PERK	no response		13	I	R	L
PERK	big	unrelated	14	I	R	L
ROVE	no response		13	I	R	L
ROVE	row	visual	14	I	R	L
SCOUR	sour	visual	1	I	R	L
SCOUR	score	visual	7	I	R	L

Target	Production	Error Type	Participant	B	R	F
SCOUR	[skəʊ]	phonological	8	I	R	L
SCOUR	scorn	visual	10	I	R	L
SCOUR	sour	visual	11	I	R	L
SCOUR	snow	initial letter	13	I	R	L
SCOUR	stout	mde	14	I	R	L
SLOUCH	[slɒtʃ]	phonological	2	I	R	L
SLOUCH	[slɔç]	neologism	5	I	R	L
SLOUCH	[skrotʃ]	phonological	6	I	R	L
SLOUCH	[slos]	neologism	7	I	R	L
SLOUCH	sloth	mde	10	I	R	L
SLOUCH	[slɔʊtʃ]	phonological	11	I	R	L
SLOUCH	slow	mde	13	I	R	L
STOW	snow	visual	10	I	R	L
STOW	no response		11	I	R	L
STOW	sour	perseveration	14	I	R	L
TOAD	toads	derivational	7	I	R	L
TOAD	no response		13	I	R	L
TOAD	tone	initial letter	14	I	R	L
YARN	[jɔ̃]	neologism	10	I	R	L
BULL	bill	visual	13	I	I	H
COME	comb	visual	11	I	I	H
COUGH	cloud	mde	13	I	I	H
DREAD	bread	visual	7	I	I	H
DREAD	bread	visual	13	I	I	H
DWARF	draught	initial letter	13	I	I	H
HARD	harm	visual	10	I	I	H
STEAK	steaks	derivational	7	I	I	H
TOMB	tombs	derivational	7	I	I	H

Target	Production	Error Type	Participant	B	R	F
TOMB	tom	visual	10	I	I	H
TOMB	comb	visual	13	I	I	H
WEAR	weigh	initial letter	7	I	I	H
WEAR	swear	visual	8	I	I	H
WEAR	[wʌrmf]	neologism	10	I	I	H
WHERE	heard	unrelated	2	I	I	H
WHERE	were	visual	10	I	I	H
WHERE	wheat	visual	13	I	I	H
WHO	Hugh	phonological	7	I	I	H
WHO	you	mde	13	I	I	H
DEARTH	no response		7	I	I	L
DEARTH	earth	visual	8	I	I	L
DEARTH	[dɪrð]	phonological	10	I	I	L
DEARTH	dearths	derivational	11	I	I	L
DEARTH	breath	visual	13	I	I	L
DROWN	drowned	derivational	13	I	I	L
GASP	[gɒsp]	phonological	10	I	I	L
GASP	grasp	visual	13	I	I	L
HEWN	hew	derivational	2	I	I	L
HEWN	sew	mde	7	I	I	L
HEWN	heathen	initial letter	10	I	I	L
HEWN	hew	derivational	12	I	I	L
HEWN	no response		13	I	I	L
SHONE	shown	mde	9	I	I	L
SHONE	summer	semantic	10	I	I	L
SHONE	shine	derivational	12	I	I	L
SHONE	stone	visual	14	I	I	L
SOOT	soft	visual	13	I	I	L
TON	[tan]	phonological	1	I	I	L

Target	Production	Error Type	Participant	B	R	F
TON	fun	phonological	7	I	I	L
TON	tom	visual	10	I	I	L
TON	don	visual	13	I	I	L
TON	ten	visual	14	I	I	L
WOW	woe	visual	3	I	I	L
WOW	woof	visual	10	I	I	L
WOW	way	initial letter	13	I	I	L
WOW	how	visual	14	I	I	L
BILGE	no response		13	U	I	H
BILGE	[pɪldʒ]	phonological	8	U	I	L
BILGE	[bɪldð]	phonological	10	U	I	L
BILGE	bulge	visual	14	U	I	L
BULB	bulbs	derivational	7	U	R	H
BULB	[bʊzl]	neologism	10	U	R	H
DEBT	debit	mde	2	U	R	H
DEBT	debit	mde	5	U	R	H
DEBT	debts	derivational	7	U	R	H
DEBT	deb	visual	10	U	R	H
DEBT	debit	mde	11	U	R	H
DEBT	debate	visual	14	U	R	H
DESK	[dɛks]	phonological	11	U	R	H
DOUBT	double	visual	10	U	R	H
DOUBT	[dʌljʊ]	neologism	13	U	R	H
SAUCE	salt	mde	12	U	R	H
SAUCE	saucy	derivational	14	U	R	H
SOAP	soup	visual	14	U	R	H
STYLE	stow	neologism	7	U	R	H
STYLE	[stal]	phonological	10	U	R	H

Target	Production	Error Type	Participant	B	R	F
STYLE	[saɪəl]	phonological	13	U	R	H
TYPE	tape	visual	1	U	R	H
TYPE	typewri..	phonological	12	U	R	H
VEIL	vein	visual	1	U	R	H
VEIL	no response		7	U	R	H
VEIL	[vɪfə]	neologism	10	U	R	H
BURNT	burn	derivational	11	U	R	L
BURNT	burn	derivational	13	U	R	L
CHIRP	[tʌrnɪt]	neologism	7	U	R	L
CHIRP	[tʃəndə]	neologism	10	U	R	L
CHIRP	chip	visual	11	U	R	L
CHIRP	cheap	visual	12	U	R	L
CHIRP	no response		13	U	R	L
CLOTHE	cloth	derivational	5	U	R	L
CLOTHE	clothes	derivational	6	U	R	L
CLOTHE	close	derivational	7	U	R	L
CLOTHE	clothes	derivational	11	U	R	L
CLOTHE	cloth	derivational	12	U	R	L
CLOTHE	clothes	derivational	13	U	R	L
CLOTHE	clothes	derivational	14	U	R	L
CUSP	crisp	visual	6	U	R	L
CUSP	crisps	mde	7	U	R	L
CUSP	cube	visual	12	U	R	L
CUSP	grip	unrelated	13	U	R	L
DUCT	dunk	visual	6	U	R	L
DUCT	duck	visual	7	U	R	L
DUCT	duck	visual	10	U	R	L
DUCT	duel	visual	12	U	R	L
DUCT	no response		13	U	R	L

Target	Production	Error Type	Participant	B	R	F
FUGUE	[fʊdʒɪ]	neologism	3	U	R	L
FUGUE	fatigue	visual	5	U	R	L
FUGUE	feud	initial letter	6	U	R	L
FUGUE	no response		7	U	R	L
FUGUE	[fjʊmə]	neologism	10	U	R	L
FUGUE	[fjʊgəl]	neologism	12	U	R	L
FUGUE	[fʌtʃɪf]	neologism	13	U	R	L
FUGUE	future	initial letter	14	U	R	L
FURZE	[Øʌrə]	neologism	2	U	R	L
FURZE	furzy	visual	5	U	R	L
FURZE	[fjʌrʌmbələ]	neologism	10	U	R	L
FURZE	fuzzy	mde	11	U	R	L
FURZE	fern	semantic	13	U	R	L
FURZE	[fɪzrə]	neologism	14	U	R	L
GAUZE	[gɑzə]	phonological	10	U	R	L
GAUZE	[gɔʃ]	perseveration	12	U	R	L
GAUZE	glance	initial letter	13	U	R	L
GRIEVE	grief	derivational	10	U	R	L
GRIEVE	no response		13	U	R	L
KILN	kin	visual	3	U	R	L
KILN	kill	visual	6	U	R	L
KILN	[kɪlən]	phonological	7	U	R	L
KILN	kilt	visual	13	U	R	L
KILN	Kim	visual	14	U	R	L
KNOSP	[nɪsp]	phonological	1	U	R	L
KNOSP	[knɒsp]	phonological	3	U	R	L
KNOSP	[nɒʃp]	phonological	4	U	R	L

Target	Production	Error Type	Participant	B	R	F
KNOSP	nose	mde	5	U	R	L
KNOSP	noise	mde	7	U	R	L
KNOSP	[maɪnz]	neologism	10	U	R	L
KNOSP	no response		13	U	R	L
KNOSP	knock	visual	14	U	R	L
LEASH	[dɪsə]	neologism	8	U	R	L
LEASH	[lɪrð]	neologism	10	U	R	L
LEASH	no response		13	U	R	L
LOATHE	[loð]	phonological	5	U	R	L
LOATHE	love	semantic	10	U	R	L
LOATHE	no response		13	U	R	L
MOSQUE	no response		7	U	R	L
MOSQUE	mosquito	visual	10	U	R	L
MOSQUE	mosaic	initial letter	12	U	R	L
MOSQUE	[mɒs]	phonological	14	U	R	L
NOUN	verb	semantic	10	U	R	L
NOUN	no response		13	U	R	L
NOUN	mould	unrelated	14	U	R	L
PEACE	paste	initial letter	14	U	R	L
PHLEGM	no response	letter-by-letter	5	U	R	L
PHLEGM	no response		7	U	R	L
PHLEGM	no response		12	U	R	L
PHLEGM	no response		13	U	R	L
TWERP	[bardip]	neologism	1	U	R	L
TWERP	[twɪrlə]	neologism	10	U	R	L
TWERP	use	unrelated	12	U	R	L
TWERP	no response		13	U	R	L
ZINC	[skɪnk]	phonological	14	U	R	L

Target	Production	Error Type	Participant	B	R	F
AISLE	[asəɹ]	neologism	10	U	I	H
AISLE	a.i.s.	letter-by-letter	12	U	I	H
AISLE	Ainsley	visual	13	U	I	H
COURT	curler	initial letter	10	U	I	H
CURVE	curd	visual	7	U	I	H
CURVE	[kʌrvə]	phonological	10	U	I	H
CURVE	no response		13	U	I	H
CURVE	give	unrelated	14	U	I	H
GAOL	goal	visual	1	U	I	H
GAOL	goal	visual	5	U	I	H
GAOL	goal	visual	10	U	I	H
GAOL	goal	visual	12	U	I	H
GAOL	goal	visual	13	U	I	H
HEART	hear	visual	10	U	I	H
MYRRH	mirth	initial letter	4	U	I	H
MYRRH	no response		7	U	I	H
MYRRH	[maɪrə]	neologism	10	U	I	H
MYRRH	no response		13	U	I	H
PRIEST	p.r.i.e.s.t.	letter-by-letter	9	U	I	H
QUEUE	query	visual	10	U	I	H
QUEUE	crew	phonological	13	U	I	H
QUEUE	quit	initial letter	14	U	I	H
SEARCH	[sɛʃ]	phonological	8	U	I	H
SEARCH	rescue	semantic	10	U	I	H
SEARCH	[sərks]	phonological	11	U	I	H
TONGUE	[tʌndʒʊ]	neologism	13	U	I	H
TONGUE	tone	visual	14	U	I	H
BILGE	bulge	visual	6	U	I	L
BILGE	no response		7	U	I	L

Target	Production	Error Type	Participant	B	R	F
BUOY	no response		13	U	I	L
BUOY	bowl	initial letter	14	U	I	L
DRACHM	[diprɛt]	neologism	1	U	I	L
DRACHM	drachma	visual	2	U	I	L
DRACHM	[draçəm]	phonological	3	U	I	L
DRACHM	drachma	visual	4	U	I	L
DRACHM	[draʃm]	phonological	5	U	I	L
DRACHM	drachma	visual	6	U	I	L
DRACHM	no response		7	U	I	L
DRACHM	[draçəm]	phonological	9	U	I	L
DRACHM	[brakəm]	neologism	10	U	I	L
DRACHM	no response		11	U	I	L
DRACHM	[drakmɪf]	neologism	12	U	I	L
DRACHM	no response		13	U	I	L
GAUCHE	[giçə]	neologism	1	U	I	L
GAUCHE	[gɔχɪ]	neologism	3	U	I	L
GAUCHE	gouge	initial letter	4	U	I	L
GAUCHE	no response		5	U	I	L
GAUCHE	no response		7	U	I	L
GAUCHE	[gotʃ]	neologism	8	U	I	L
GAUCHE	golf	initial letter	10	U	I	L
GAUCHE	juice	unrelated	11	U	I	L
GAUCHE	[gɔʃ]	phonological	12	U	I	L
GAUCHE	no response		13	U	I	L
HEARSE	[hars]	phonological	8	U	I	L
HEARSE	hears	phonological	10	U	I	L
HEARSE	hearth	visual	12	U	I	L
HEARSE	horse	mde	14	U	I	L

Target	Production	Error Type	Participant	B	R	F
NEWT	[mjʌt]	neologism	7	U	I	L
NEWT	[hjʊm]	neologism	11	U	I	L
NEWT	no response		13	U	I	L
NEWT	new	visual	14	U	I	L
SUEDE	swede	visual	2	U	I	L
SUEDE	suave	mde	12	U	I	L
SUEDE	swede	visual	13	U	I	L
SUEDE	squeeze	initial letter	14	U	I	L
YACHT	[jəʊd]	neologism	10	U	I	L

PSEUDOWORD ERRORS

Target	Production	Error Type	Participant	Body
BINK	brink	visual lexicalisation	6	C
BINK	bank	visual lexicalisation	7	C
BINK	[bʌmi]	far from target	10	C
BUEL	gruel	visual lexicalisation	2	C
BUEL	duel	visual lexicalisation	4	C
BUEL	tape	perseveration	7	C
BUEL	no response		8	C
BUEL	[bil]	near to target	10	C
CHAKE	[kɛɪkə]	near to target	1	C
CHAKE	shake	visual lexicalisation	4	C
CHAKE	shack	lexicalisation	5	C
CHAKE	no response		7	C
CHAKE	quick	lexicalisation	8	C
CHAKE	choke	visual lexicalisation	10	C
CLORT	[tʃɔrt]	near to target	1	C
CLORT	[klɔrɪt]	near to target	2	C
CLORT	[slɔrt]	near to target	5	C
CLORT	s.t.o.	letter-by-letter	6	C
CLORT	cloth	visual lexicalisation	7	C
CLORT	[lɔrt]	near to target	8	C
CLORT	[lɔŋs]	far from target	10	C
COUT	coat	visual lexicalisation	1	C
COUT	grout	visual lexicalisation	2	C
COUT	court	visual lexicalisation	3	C
COUT	[kɛt]	near to target	4	C
COUT	gout	visual lexicalisation	6	C

Target	Production	Error Type	Participant	Body
COUT	count	visual lexicalisation	7	C
COUT	scout	visual lexicalisation	8	C
COUT	[kit]	near to target	9	C
COUT	cough	visual lexicalisation	10	C
CRANCE	[kran]	near to target	3	C
CRANCE	[krantʃ]	near to target	6	C
CRANCE	niece	perseveration	7	C
CRANCE	[transɛla]	far from target	10	C
CRILL	grills	lexicalisation	7	C
CRILL	[kralə]	far from target	10	C
DIST	[dɪs]	far from target	2	C
DIST	disk	visual lexicalisation	7	C
DIST	disk	visual lexicalisation	8	C
DIST	dish	visual lexicalisation	10	C
DOAST	boast	visual lexicalisation	1	C
DOAST	toast	visual lexicalisation	2	C
DOAST	[dɒʃk]	far from target	3	C
DOAST	toast	visual lexicalisation	4	C
DOAST	dust	visual lexicalisation	7	C
DOAST	roast	visual lexicalisation	8	C
DOAST	dozed	phonological lexicalisation	9	C
DOAST	[slɔstə]	far from target	10	C
FARK	fart	visual lexicalisation	7	C
FARK	[firk]	near to target	10	C
FORN	four	visual lexicalisation	2	C
FORN	form	visual lexicalisation	3	C
FORN	[farn]	near to target	7	C
FREDGE	[frɛdʒrɪ]	near to target	1	C

Target	Production	Error Type	Participant	Body
FREDGE	fudge	visual lexicalisation	3	C
FREDGE	[fɛdʒ]	near to target	4	C
FREDGE	no response		5	C
FREDGE	fridge	visual lexicalisation	7	C
FREDGE	[frɛdə]	near to target	10	C
FRICK	[frɪg]	near to target	2	C
FRICK	figs	lexicalisation	7	C
FRICK	crick	visual lexicalisation	10	C
FRIECE	[tʃiɛsɑ]	far from target	1	C
FRIECE	[fridʒ]	far from target	2	C
FRIECE	freeze	phonological lexicalisation	3	C
FRIECE	freeze	phonological lexicalisation	5	C
FRIECE	niece	visual lexicalisation	7	C
FRIECE	niece	visual lexicalisation	8	C
FRIECE	[frɛnz]	far from target	10	C
FULP	[fʌtʌlp]	near to target	2	C
FULP	[fʌlk]	near to target	3	C
FULP	[flʌp]	near to target	4	C
FULP	no response		7	C
FULP	[fʌlk]	near to target	8	C
FULP	[fʌlə]	near to target	10	C
GACT	[gɑt]	near to target	2	C
GACT	[gant]	near to target	4	C
GACT	[gɑk]	near to target	6	C
GACT	Kate	lexicalisation	7	C
GACT	[gars]	far from target	10	C
GUG	[gʌk]	near to target	2	C

Target	Production	Error Type	Participant	Body
GUG	[glʌd]	far from target	7	C
GUG	gulp	visual lexicalisation	10	C
JIGHT	tight	visual lexicalisation	1	C
JIGHT	fight	visual lexicalisation	2	C
JIGHT	jig	visual lexicalisation	3	C
JIGHT	jilt	visual lexicalisation	5	C
JIGHT	no response		7	C
JIGHT	[daɪt]	near to target	8	C
JIGHT	[dʒɪnksə]	far from target	10	C
KNEND	[glɛnd]	near to target	1	C
KNEND	net	lexicalisation	2	C
KNEND	neat	lexicalisation	3	C
KNEND	[kɛnd]	near to target	4	C
KNEND	kneel	visual lexicalisation	7	C
KNEND	mend	visual lexicalisation	8	C
KNEND	[ninz]	far from target	10	C
LAIL	[lil]	near to target	3	C
LAIL	[laɪl]	near to target	4	C
LAIL	[lil]	near to target	5	C
LAIL	hail	visual lexicalisation	7	C
LAIL	nail	visual lexicalisation	8	C
LAIL	[lal]	near to target	10	C
LESH	[əlɛʃi]	near to target	2	C
LESH	leash	visual lexicalisation	4	C
LESH	lash	visual lexicalisation	6	C
LESH	leaf	visual lexicalisation	7	C
LESH	[lɛkə]	far from target	10	C

Target	Production	Error Type	Participant	Body
LIRL	skirt	visual lexicalisation	2	C
LIRL	live	visual lexicalisation	3	C
LIRL	girl	visual lexicalisation	7	C
LIRL	twirl	visual lexicalisation	8	C
LIRL	lark	lexicalisation	10	C
LURN	[lɔrn]	near to target	1	C
LURN	no response		6	C
LURN	[l̥arn]	near to target	7	C
LURN	lark	lexicalisation	10	C
MECK	meek	visual lexicalisation	2	C
MECK	meek	visual lexicalisation	4	C
MECK	neck	visual lexicalisation	7	C
MECK	neck	visual lexicalisation	8	C
MECK	[mɛnkə]	near to target	10	C
MEPT	[mapt]	near to target	1	C
MEPT	[prɛmt]	far from target	2	C
MEPT	[mɛp]	near to target	3	C
MEPT	[nɛpt]	near to target	4	C
MEPT	met	far from target	5	C
MEPT	wept	visual lexicalisation	6	C
MEPT	[wɛp]	far from target	7	C
MEPT	[mɛmp]	near to target	10	C
NAIN	nine	phonological lexicalisation	1	C
NAIN	ten	far from target	2	C
NAIN	main	visual lexicalisation	3	C
NAIN	main	visual lexicalisation	4	C
NAIN	Nairn	visual lexicalisation	7	C
NAIN	[nin]	near to target	8	C

Target	Production	Error Type	Participant	Body
NAIN	[nɑns]	far from target	10	C
NALM	[tamə]	far from target	2	C
NALM	balm	visual lexicalisation	3	C
NALM	c.o.l.m.	letter-by-letter	6	C
NALM	palm	visual lexicalisation	7	C
NALM	palm	visual lexicalisation	8	C
NALM	[lanə]	far from target	10	C
NARGE	[nadʒi]	far from target	2	C
NARGE	[mɑrdʒi]	near to target	4	C
NARGE	marge	visual lexicalisation	5	C
NARGE	[gardʒ]	near to target	6	C
NARGE	nails	perseveration	7	C
NARGE	marge	visual lexicalisation	8	C
NARGE	[nardə]	near to target	10	C
NEIGN	[nɛɪgəni]	far from target	1	C
NEIGN	neigh	visual lexicalisation	2	C
NEIGN	[nɪkt]	far from target	5	C
NEIGN	no response		6	C
NEIGN	girl	lexicalisation	7	C
NEIGN	reign	visual lexicalisation	8	C
NEIGN	[nɛstə]	far from target	10	C
NIQUE	[nɪçt]	near to target	3	C
NIQUE	[nɪsk]	far from target	5	C
NIQUE	no response		6	C
NIQUE	dancing	lexicalisation	7	C
NIQUE	[kifə]	far from target	10	C
PLAW	plough	lexicalisation	1	C

Target	Production	Error Type	Participant	Body
PLAW	plough	lexicalisation	2	C
PLAW	[plɑv]	far from target	3	C
PLAW	plough	lexicalisation	4	C
PLAW	Paul	phonological lexicalisation	6	C
PLAW	paw	visual lexicalisation	7	C
PLAW	[daw]	far from target	8	C
PLAW	[pɪlɑ]	far from target	10	C
POAT	boat	phonological lexicalisation	2	C
POAT	[pɔnt]	near to target	4	C
POAT	boat	visual lexicalisation	5	C
POAT	poem	visual lexicalisation	7	C
POAT	goat	visual lexicalisation	8	C
POAT	poach	visual lexicalisation	10	C
QUEE	[kwɔ]	near to target	1	C
QUEE	no response		5	C
QUEE	queue	visual lexicalisation	7	C
QUEE	q.u.e.e.	letter-by-letter	9	C
QUEE	[wi]	near to target	10	C
RELT	[rɛlit]	far from target	2	C
RELT	[tɛlt]	near to target	6	C
RELT	rent	visual lexicalisation	7	C
RELT	[rɛlf]	near to target	10	C
RENE	[riə]	far from target	2	C
RENE	[rinə]	near to target	7	C
RENE	[rɑtɪvə]	far from target	10	C
SHENT	[ʃhɛnk]	near to target	1	C
SHENT	[tʃɛt]	far from target	2	C

Target	Production	Error Type	Participant	Body
SHENT	shed	visual lexicalisation	7	C
SHENT	dent	visual lexicalisation	8	C
SHENT	sheen	visual lexicalisation	10	C
SICE	[snaɪs]	near to target	2	C
SICE	dice	visual lexicalisation	4	C
SICE	nice	visual lexicalisation	6	C
SICE	no response		7	C
SICE	cease	phonological lexicalisation	8	C
SKILE	sleight	lexicalisation	2	C
SKILE	skill	visual lexicalisation	5	C
SKILE	skill	visual lexicalisation	6	C
SKILE	[skʌrl]	far from target	7	C
SKILE	[slil]	near to target	10	C
SLOAX	[slɛʊzə]	far from target	2	C
SLOAX	[sɔlɑks]	near to target	3	C
SLOAX	slacks	phonological lexicalisation	4	C
SLOAX	[slɒk]	near to target	6	C
SLOAX	slow	lexicalisation	7	C
SLOAX	slothe	visual lexicalisation	10	C
SLURE	slur	visual lexicalisation	4	C
SLURE	[slɔr]	near to target	7	C
SLURE	slurp	visual lexicalisation	10	C
SNATE	skate	visual lexicalisation	2	C
SNATE	slate	visual lexicalisation	3	C
SNATE	snake	visual lexicalisation	6	C
SNATE	mate	lexicalisation	7	C
SNATE	[snɛrt]	near to target	9	C
SNATE	[snart]	near to target	10	C

Target	Production	Error Type	Participant	Body
TADE	tape	visual lexicalisation	7	C
TADE	take	visual lexicalisation	10	C
THIT	tit	visual lexicalisation	1	C
THIT	think	visual lexicalisation	2	C
THIT	this	visual lexicalisation	3	C
THIT	no response		6	C
THIT	there	lexicalisation	7	C
THIT	hit	visual lexicalisation	8	C
THIT	[ðɛt]	near to target	10	C
TRINCH	[trʌntʃ]	near to target	2	C
TRINCH	[trɪçt]	far from target	3	C
TRINCH	[prɪntʃ]	near to target	5	C
TRINCH	[krɪntʃ]	near to target	6	C
TRINCH	[trʌntʃ]	near to target	7	C
TRINCH	trick	visual lexicalisation	10	C
TUILT	tulip	lexicalisation	2	C
TUILT	[tʃʊlt]	near to target	3	C
TUILT	tilt	visual lexicalisation	5	C
TUILT	no response		7	C
TUILT	quilt	visual lexicalisation	8	C
TUILT	[tʃʌlt]	near to target	9	C
TUILT	[tʌlfə]	near to target	10	C
TWIFF	[kwif]	near to target	2	C
TWIFF	tiff	visual lexicalisation	3	C
TWIFF	[tif]	near to target	4	C
TWIFF	[swɪf]	far from target	5	C
TWIFF	turn	lexicalisation	7	C

Target	Production	Error Type	Participant	Body
TWIFF	[dwɪf]	near to target	8	C
TWIFF	twin	visual lexicalisation	10	C
WHOB	hoop	lexicalisation	1	C
WHOB	who	visual lexicalisation	2	C
WHOB	[wʌb]	far from target	3	C
WHOB	[wʌb]	near to target	4	C
WHOB	[flɒb]	near to target	6	C
WHOB	whop	visual lexicalisation	7	C
WHOB	hob	visual lexicalisation	8	C
WURN	warn	visual lexicalisation	3	C
WURN	warn	visual lexicalisation	5	C
WURN	[mʌrm]	near to target	6	C
WURN	worm	phonological lexicalisation	7	C
WURN	[swʌrn]	near to target	8	C
WURN	warmth	lexicalisation	10	C
XANG	[zɑŋə]	near to target	1	C
XANG	sank	lexicalisation	2	C
XANG	sang	visual lexicalisation	3	C
XANG	[k.s.a.ŋ.]	letter-by-letter	5	C
XANG	no response		6	C
XANG	woman	perseveration	7	C
XANG	gang	visual lexicalisation	8	C
XANG	[zɛŋ]	near to target	9	C
XANG	[nɛfɑ]	far from target	10	C
ZUB	[zʊpə]	near to target	1	C
ZUB	sub	visual lexicalisation	3	C
ZUB	no response		7	C

Target	Production	Error Type	Participant	Body
ZUB	[lʌbə]	far from target	10	C
BOVE	[nɔm]	far from target	2	I
BOVE	bow	visual lexicalisation	7	I
BOVE	love	visual lexicalisation	8	I
BOVE	[bɔv]	near to target	9	I
BOVE	[bʌvə]	near to target	10	I
BROSS	brass	visual lexicalisation	3	I
BROSS	brother	visual lexicalisation	7	I
BROSS	[brɔsə]	near to target	10	I
CEARTH	dearth	phonological lexicalisation	2	I
CEARTH	[garØ]	far from target	5	I
CEARTH	hearth	visual lexicalisation	6	I
CEARTH	harsh	lexicalisation	7	I
CEARTH	earth	visual lexicalisation	8	I
CEARTH	[sirsə]	near to target	10	I
CHON	corn	lexicalisation	1	I
CHON	chalk	phonological lexicalisation	2	I
CHON	coin	lexicalisation	3	I
CHON	shown	phonological lexicalisation	5	I
CHON	shone	lexicalisation	7	I
CHON	[hɒn]	near to target	8	I
CHON	[snɔrk]	perseveration	10	I
CHONE	shown	phonological lexicalisation	1	I
CHONE	[tʃʌnʌm]	far from target	2	I
CHONE	shown	phonological lexicalisation	4	I
CHONE	no response		5	I
CHONE	crone	visual lexicalisation	6	I
CHONE	rome	lexicalisation	7	I

Target	Production	Error Type	Participant	Body
CHONE	zone	visual lexicalisation	8	I
CHONE	[tʃʌnz]	far from target	10	I
CORSE	[kʊrsə]	near to target	1	I
CORSE	no response		5	I
CORSE	no response		6	I
CORSE	horse	visual lexicalisation	8	I
CORSE	[kɔrsi]	near to target	10	I
DEAK	deck	visual lexicalisation	4	I
DEAK	desk	visual lexicalisation	7	I
DINTH	dinner	visual lexicalisation	2	I
DINTH	[dɪØ]	near to target	3	I
DINTH	[gəɪnɪØ]	far from target	5	I
DINTH	[dɛnØ]	near to target	6	I
DINTH	juice	lexicalisation	7	I
DINTH	ninth	visual lexicalisation	8	I
DINTH	[dɪØ]	near to target	9	I
DINTH	[dɪnz]	near to target	10	I
FARN	farm	visual lexicalisation	5	I
FARN	farm	visual lexicalisation	7	I
FARN	[farə]	near to target	10	I
FINT	flint	visual lexicalisation	2	I
FINT	flint	visual lexicalisation	7	I
FINT	thin	lexicalisation	10	I
FO	[fɛ]	near to target	2	I
FO	[fʊ]	near to target	3	I
FO	flow	phonological lexicalisation	7	I
FO	[ɒv]	far from target	10	I

Target	Production	Error Type	Participant	Body
FOUP	[pɔf]	far from target	2	I
FOUP	[fiʊp]	near to target	5	I
FOUP	soup	visual lexicalisation	6	I
FOUP	soup	visual lexicalisation	7	I
FOUP	[fʌlbə]	far from target	10	I
FOW	[fɔ]	near to target	2	I
FOW	bow	visual lexicalisation	7	I
FOW	[fɔrə]	far from target	10	I
GAND	no response		1	I
GAND	no response		2	I
GAND	no response		3	I
GAND	gland	visual lexicalisation	4	I
GAND	gang	visual lexicalisation	6	I
GAND	no response		7	I
GAND	no response		10	I
GASTE	[gastɛɪ]	near to target	1	I
GASTE	[gɔst]	near to target	4	I
GASTE	ghost	phonological lexicalisation	6	I
GASTE	no response		7	I
GASTE	waste	visual lexicalisation	8	I
GASTE	[gɪst]	near to target	9	I
GASTE	guess	lexicalisation	10	I
GEAF	[dʒɪaf]	near to target	1	I
GEAF	[dʒizə]	far from target	2	I
GEAF	deaf	visual lexicalisation	3	I
GEAF	[tif]	near to target	4	I
GEAF	[geɪɑf]	near to target	5	I

Target	Production	Error Type	Participant	Body
GEAF	leaf	visual lexicalisation	6	I
GEAF	rain	lexicalisation	7	I
GEAF	deaf	visual lexicalisation	8	I
GIMB	[sɪmbə]	near to target	1	I
GIMB	[gʌmbi]	near to target	2	I
GIMB	[gɪmbə]	near to target	5	I
GIMB	[gɪmbəl]	near to target	6	I
GIMB	no response		7	I
GIMB	[gɪmbə]	near to target	9	I
GIMB	[gɪmbi]	near to target	10	I
GOOT	gout	visual lexicalisation	3	I
GOOT	goats	lexicalisation	7	I
GOOT	[gʊni]	far from target	10	I
GOOTH	[gʊ]	near to target	2	I
GOOTH	[gʊʃ]	near to target	3	I
GOOTH	[gʊʃ]	near to target	5	I
GOOTH	tooth	visual lexicalisation	7	I
GOUCH	[gʌtʃ]	near to target	1	I
GOUCH	[gəʊç]	near to target	3	I
GOUCH	[gɔç]	far from target	5	I
GOUCH	gout	visual lexicalisation	7	I
GOUCH	course	lexicalisation	10	I
GOUGH	[goagə]	near to target	1	I
GOUGH	gouge	visual lexicalisation	2	I
GOUGH	cough	visual lexicalisation	4	I
GOUGH	no response		6	I
GOUGH	no response		7	I

Target	Production	Error Type	Participant	Body
GOUGH	no response		8	I
GOUGH	[gʌrla]	far from target	10	I
HARCE	arse	phonological lexicalisation	2	I
HARCE	harsh	visual lexicalisation	3	I
HARCE	harsh	visual lexicalisation	4	I
HARCE	harsh	phonological lexicalisation	6	I
HARCE	horse	visual lexicalisation	7	I
HARCE	farce	visual lexicalisation	8	I
HARCE	[harkə]	near to target	10	I
KEAD	knead	visual lexicalisation	2	I
KEAD	no response	visual lexicalisation	4	I
KEAD	heed	phonological lexicalisation	5	I
KEAD	knead	visual lexicalisation	7	I
KEAD	keep	visual lexicalisation	10	I
KIVE	knife	visual lexicalisation	2	I
KIVE	knife	visual lexicalisation	7	I
KIVE	five	visual lexicalisation	8	I
KIVE	[kif]	near to target	10	I
KUISE	[kwizə]	near to target	1	I
KUISE	disguise	visual lexicalisation	2	I
KUISE	[kwɪʃ]	far from target	3	I
KUISE	[kwiz]	far from target	4	I
KUISE	[gɪz]	far from target	5	I
KUISE	guise	visual lexicalisation	6	I
KUISE	no response		7	I
KUISE	guise	visual lexicalisation	8	I
KUISE	[kʊiz]	near to target	9	I
KUISE	[kjʊisɑ]	far from target	10	I

Target	Production	Error Type	Participant	Body
LERK	[lɛɪrək]	near to target	1	I
LERK	sell	lexicalisation	2	I
LERK	no response		6	I
LERK	[larg]	far from target	7	I
LERK	[likə]	far from target	10	I
LOLF	[lɔlə]	far from target	2	I
LOLF	loaf	visual lexicalisation	3	I
LOLF	loaf	visual lexicalisation	4	I
LOLF	no response		5	I
LOLF	[lɪf]	near to target	6	I
LOLF	loaf	visual lexicalisation	7	I
LOLF	wolf	visual lexicalisation	8	I
LOLF	[lɪf]	near to target	10	I
LORSE	[lɔr]	near to target	2	I
LORSE	horse	visual lexicalisation	7	I
LORSE	lose	visual lexicalisation	8	I
LORSE	[lɔrst]	near to target	9	I
LORSE	Laura	perseveration	10	I
LOUR	glour	visual lexicalisation	2	I
LOUR	brush	lexicalisation	7	I
LOUR	Laura	lexicalisation	10	I
MOMB	mamba	lexicalisation	1	I
MOMB	[mɔmbə]	visual lexicalisation	2	I
MOMB	mob	visual lexicalisation	3	I
MOMB	[mɔmbə]	far from target	4	I
MOMB	[mɔmbə]	near to target	5	I
MOMB	no response		7	I
MOMB	womb	visual lexicalisation	8	I

Target	Production	Error Type	Participant	Body
MOUGH	[mʊdʒʌŋ]	far from target	2	I
MOUGH	m.u.g.h.	letter-by-letter	5	I
MOUGH	mouth	visual lexicalisation	6	I
MOUGH	mouth	visual lexicalisation	7	I
MOUGH	[mʌfə]	far from target	10	I
MURY	marry	lexicalisation	2	I
MURY	[nʌri]	near to target	5	I
MURY	[mɔri]	near to target	7	I
MURY	[snɛrk]	far from target	10	I
NAR	[nɛr]	near to target	4	I
NAR	drain	lexicalisation	7	I
NAS	[nars]	near to target	2	I
NAS	[nɑʃ]	near to target	3	I
NAS	house	lexicalisation	7	I
NAS	gas	visual lexicalisation	8	I
NAS	[nɑns]	perseveration	10	I
NERK	keek	lexicalisation	2	I
NERK	[gɛrk]	near to target	6	I
NERK	neck	visual lexicalisation	7	I
NERK	[nɛrf]	near to target	10	I
NOWL	noel	visual lexicalisation	2	I
NOWL	null	lexicalisation	3	I
NOWL	[raʊl]	near to target	6	I
NOWL	rowan	perseveration	7	I
NOWL	null	lexicalisation	10	I
PANGE	pang	visual lexicalisation	1	I
PANGE	pan	visual lexicalisation	2	I

Target	Production	Error Type	Participant	Body
PANGE	sponge	lexicalisation	7	I
PANGE	[baŋə]	near to target	9	I
PANGE	[pagə]	near to target	10	I
PAUNT	[pɔg]	far from target	2	I
PAUNT	punt	visual lexicalisation	4	I
PAUNT	pants	lexicalisation	7	I
PAUNT	[mɔnt]	near to target	8	I
PAUNT	[pat]	near to target	9	I
PAUNT	cough	perseveration	10	I
PLARE	[pɛɪtər]	far from target	2	I
PLARE	plain	visual lexicalisation	3	I
PLARE	glare	visual lexicalisation	5	I
PLARE	paid	lexicalisation	7	I
PLARE	[planð]	far from target	10	I
PLEW	ply	visual lexicalisation	2	I
PLEW	plough	lexicalisation	5	I
PLEW	pure	visual lexicalisation	6	I
PLEW	flew	visual lexicalisation	7	I
PLEW	no response		8	I
PLEW	[lavi]	far from target	10	I
RILD	[rɪl]	near to target	2	I
RILD	[rɪl]	near to target	6	I
RILD	ride	visual lexicalisation	7	I
RILD	mild	visual lexicalisation	8	I
RILD	[lʌp]	far from target	10	I
ROWN	round	phonological lexicalisation	2	I
ROWN	rowen	visual lexicalisation	7	I
ROWN	row	visual lexicalisation	10	I

Target	Production	Error Type	Participant	Body
SARD	sardine	visual lexicalisation	2	I
SARD	shard	visual lexicalisation	4	I
SARD	sword	phonological lexicalisation	7	I
SARD	guard	visual lexicalisation	8	I
SARD	[sardi]	near to target	10	I
SLASP	[glɑsp]	near to target	2	I
SLASP	slap	visual lexicalisation	3	I
SLASP	[slɑps]	near to target	4	I
SLASP	clasp	visual lexicalisation	5	I
SLASP	[slɑzəm]	far from target	6	I
SLASP	slap	visual lexicalisation	7	I
SLASP	wasp	visual lexicalisation	8	I
SLASP	[salɑ]	far from target	10	I
SLEAR	slayer	visual lexicalisation	1	I
SLEAR	[lir]	near to target	6	I
SLEAR	dear	visual lexicalisation	8	I
SLEAR	sleek	lexicalisation	10	I
SLEIR	[fliɛr]	near to target	1	I
SLEIR	[sleɪp]	near to target	2	I
SLEIR	scare	phonological lexicalisation	7	I
SLEIR	their	visual lexicalisation	8	I
SLEIR	slay	phonological lexicalisation	9	I
SLEIR	[sliç]	far from target	10	I
SMARCE	[gmarɪn]	far from target	2	I
SMARCE	smash	visual lexicalisation	3	I
SMARCE	[ʃmars]	near to target	4	I
SMARCE	[smark]	near to target	5	I

Target	Production	Error Type	Participant	Body
SMARCE	[smartʃ]	near to target	6	I
SMARCE	smarties	visual lexicalisation	7	I
SMARCE	[mɪrz]	near to target	8	I
SMARCE	[smark]	near to target	10	I
SNULL	null	visual lexicalisation	2	I
SNULL	[ʃnʌl]	near to target	4	I
SNULL	skull	visual lexicalisation	5	I
SNULL	[snɛl]	near to target	6	I
SNULL	skull	visual lexicalisation	7	I
SNULL	skull	visual lexicalisation	8	I
SNULL	[smʌlg]	far from target	10	I
SOOCH	[sʊk]	near to target	1	I
SOOCH	[sʊdʒ]	near to target	2	I
SOOCH	[sʊʃ]	near to target	4	I
SOOCH	[sʊØ]	near to target	5	I
SOOCH	shoe	lexicalisation	7	I
SOOCH	[gʊʃ]	far from target	8	I
SOOCH	slosh	lexicalisation	10	I
SOOL	[jʊ]	near to target	2	I
SOOL	soul	visual lexicalisation	3	I
SOOL	stool	visual lexicalisation	6	I
SOOL	sew	lexicalisation	7	I
SOOL	[slʊl]	near to target	10	I
SOST	boat	perseveration	2	I
SOST	[sɔçt]	near to target	3	I
SOST	[ʃɔʃt]	near to target	4	I
SOST	cost	visual lexicalisation	6	I

Target	Production	Error Type	Participant	Body
SOST	sword	perseveration	7	I
SOST	[snɒst]	near to target	10	I
SUGE	[sʌdʒə]	near to target	1	I
SUGE	surge	visual lexicalisation	2	I
SUGE	surge	visual lexicalisation	2	I
SUGE	surge	visual lexicalisation	3	I
SUGE	surge	visual lexicalisation	3	I
SUGE	[sʌdʒ]	near to target	5	I
SUGE	surge	visual lexicalisation	5	I
SUGE	sugar	visual lexicalisation	7	I
SUGE	sugar	visual lexicalisation	7	I
SUGE	[fʊg]	near to target	8	I
SUGE	huge	visual lexicalisation	8	I
SUGE	[ʃʌg]	near to target	9	I
SUGE	[ʃʌg]	near to target	9	I
SUGE	[ʃʊrə]	far from target	10	I
SUGE	[ʃɒgə]	near to target	10	I
SWARF	[swartʃ]	near to target	6	I
SWARF	scarf	visual lexicalisation	7	I
SWARF	dwarf	visual lexicalisation	8	I
SWARF	[swirf]	near to target	9	I
SWARF	[smarf]	near to target	10	I
TEWN	[tʃʊk]	far from target	2	I
TEWN	town	visual lexicalisation	4	I
TEWN	tunes	lexicalisation	7	I
TEWN	goon	phonological lexicalisation	8	I
TEWN	tune	phonological lexicalisation	9	I

Target	Production	Error Type	Participant	Body
TEWN	[njʊəl]	far from target	10	I
THAVE	[ðaðə]	far from target	1	I
THAVE	tame	lexicalisation	2	I
THAVE	[tav]	near to target	3	I
THAVE	[ðwɛɪv]	near to target	4	I
THAVE	knave	visual lexicalisation	7	I
THAVE	have	visual lexicalisation	8	I
THAVE	[twal]	far from target	10	I
TIEVE	[tiɒvə]	near to target	1	I
TIEVE	[riv]	near to target	2	I
TIEVE	[triv]	near to target	3	I
TIEVE	[triv]	near to target	6	I
TIEVE	feat	lexicalisation	7	I
TIEVE	[tɛv]	near to target	10	I
TORM	[tɔr]	near to target	1	I
TORM	turn	lexicalisation	7	I
TORM	storm	visual lexicalisation	8	I
TORM	tum	visual lexicalisation	10	I
TREAST	[Ørist]	near to target	3	I
TREAST	[trɪtst]	near to target	4	I
TREAST	[trɔst]	near to target	5	I
TREAST	niece	perseveration	7	I
TREAST	breast	visual lexicalisation	8	I
TREAST	treasure	visual lexicalisation	10	I
TUIT	choose	lexicalisation	2	I
TUIT	[tʃʊɪt]	near to target	3	I
TUIT	tweet	phonological lexicalisation	4	I

Target	Production	Error Type	Participant	Body
TUIT	tweet	phonological lexicalisation	5	I
TUIT	[fjʊt]	near to target	6	I
TUIT	no response		7	I
TUIT	quit	visual lexicalisation	8	I
TUIT	[tʃʊɪt]	near to target	9	I
TUIT	tooth	phonological lexicalisation	10	I
TWAMP	[twɪmp]	near to target	1	I
TWAMP	[twɑp]	near to target	2	I
TWAMP	[tɑmp]	near to target	7	I
TWAMP	swamp	visual lexicalisation	8	I
TWAMP	[talɑ]	far from target	10	I
TWORD	[swɔrt]	near to target	1	I
TWORD	sword	visual lexicalisation	3	I
TWORD	sword	visual lexicalisation	4	I
TWORD	[twark]	near to target	6	I
TWORD	house	perseveration	7	I
TWORD	sword	visual lexicalisation	8	I
TWORD	[krɔrk]	far from target	10	I
WOME	womb	visual lexicalisation	2	I
WOME	womb	visual lexicalisation	3	I
WOME	woman	visual lexicalisation	7	I
WOME	womb	visual lexicalisation	8	I
WOME	[wɒmbə]	near to target	10	I
ZEAT	[seɪɑt]	near to target	1	I
ZEAT	[sɛs]	far from target	3	I
ZEAT	[zɛt]	near to target	6	I
ZEAT	neat	visual lexicalisation	7	I

Target	Production	Error Type	Participant	Body
ZEAT	geat	visual lexicalisation	8	I
ZEAT	[dratə]	far from target	10	I
ZERE	[dʒira]	far from target	2	I
ZERE	dare	visual lexicalisation	5	I
ZERE	zeal	visual lexicalisation	6	I
ZERE	no response		7	I
ZERE	sneer	phonological lexicalisation	10	I
BACHT	[bak]	near to target	2	U
BACHT	[baç]	near to target	4	U
BACHT	[bɒk]	far from target	6	U
BACHT	bark	lexicalisation	7	U
BACHT	[bakç]	near to target	10	U
BEUE	[beɪjʊeɪ]	far from target	1	U
BEUE	[bjʊt]	near to target	2	U
BEUE	bush	lexicalisation	3	U
BEUE	[bjʊn]	near to target	5	U
BEUE	queue	visual lexicalisation	7	U
BEUE	bow	phonological lexicalisation	8	U
BEUE	[biri]	far from target	9	U
BEUE	[bilə]	far from target	10	U
BIGN	big	visual lexicalisation	2	U
BIGN	[bɪŋ]	near to target	3	U
BIGN	benign	visual lexicalisation	4	U
BIGN	gurn	lexicalisation	5	U
BIGN	no response		6	U
BIGN	no response		7	U
BIGN	[bɪŋ]	near to target	9	U

Target	Production	Error Type	Participant	Body
BIGN	[bɪŋ]	near to target	10	U
BLAOL	[blɒl]	near to target	1	U
BLAOL	[bleɪdəʊ]	far from target	2	U
BLAOL	[blil]	near to target	3	U
BLAOL	[bɑlɔl]	near to target	4	U
BLAOL	[fraɪə]	far from target	5	U
BLAOL	bowl	phonological lexicalisation	6	U
BLAOL	nail	perseveration	7	U
BLAOL	[blɔ]	near to target	9	U
BLAOL	foal	lexicalisation	10	U
BRACHM	no response		1	U
BRACHM	[bramə]	near to target	2	U
BRACHM	no response		4	U
BRACHM	no response		5	U
BRACHM	[drɑkmeɪ]	far from target	6	U
BRACHM	no response		7	U
BRACHM	bracken	visual lexicalisation	8	U
BRACHM	bracken	visual lexicalisation	10	U
CHEBT	[ʃɛbt]	near to target	1	U
CHEBT	[tʃɛbɪt]	near to target	2	U
CHEBT	[ʃɛbɪt]	near to target	4	U
CHEBT	[kɛbɪt]	near to target	5	U
CHEBT	no response		7	U
CHEBT	net	phonological lexicalisation	8	U
CHEBT	[tʃɛb]	near to target	9	U
CHEBT	[tʃɛpl]	far from target	10	U
COUN	no response		2	U

Target	Production	Error Type	Participant	Body
COUN	coin	visual lexicalisation	3	U
COUN	comb	lexicalisation	7	U
COUN	[skʊn]	near to target	8	U
COUN	cough	visual lexicalisation	10	U
CYLE	seal	phonological lexicalisation	1	U
CYLE	[sɪklə]	far from target	2	U
CYLE	cycle	visual lexicalisation	3	U
CYLE	[saɪli]	near to target	5	U
CYLE	[silə]	near to target	6	U
CYLE	cycle	visual lexicalisation	7	U
CYLE	mile	visual lexicalisation	9	U
CYLE	[snɛlə]	far from target	10	U
DILGE	[dədʒ]	far from target	2	U
DILGE	[dʒɪldʒ]	near to target	3	U
DILGE	[gɪldʒ]	near to target	5	U
DILGE	[gɪldʒ]	near to target	6	U
DILGE	no response		7	U
DILGE	[daʊli]	far from target	10	U
DOSQUE	[dikjʊ]	far from target	2	U
DOSQUE	[bɑstɪk]	far from target	4	U
DOSQUE	[bɔsk]	near to target	5	U
DOSQUE	no response		7	U
DOSQUE	mosque	visual lexicalisation	8	U
DOSQUE	dusk	phonological lexicalisation	9	U
DOSQUE	[dɔswɑn]	far from target	10	U
FAUCE	[faʊʃ]	near to target	1	U
FAUCE	[fɒʃ]	near to target	3	U

Target	Production	Error Type	Participant	Body
FAUCE	[faʃʊ]	far from target	4	U
FAUCE	no response		7	U
FAUCE	fans	lexicalisation	10	U
FAUZE	[faʊɪz]	near to target	1	U
FAUZE	fuzz	phonological lexicalisation	4	U
FAUZE	fuzz	phonological lexicalisation	5	U
FAUZE	no response		7	U
FAUZE	[fɔrə]	near to target	10	U
FEGM	[fɛgən]	near to target	1	U
FEGM	feign	lexicalisation	4	U
FEGM	[bɪgɪm]	far from target	6	U
FEGM	no response		7	U
FEGM	[fɛrɪbə]	far from target	10	U
FOUBT	doubtful	lexicalisation	2	U
FOUBT	[fəʊb]	far from target	3	U
FOUBT	[fabt]	near to target	4	U
FOUBT	[fʌbɪt]	near to target	5	U
FOUBT	house	lexicalisation	7	U
FOUBT	[fʌbt]	near to target	9	U
FOUBT	[fʌt]	near to target	10	U
FOUNG	[faɪʌŋ]	near to target	1	U
FOUNG	[fʊjʌg]	far from target	2	U
FOUNG	house	perseveration	7	U
FOUNG	[fiŋ]	near to target	9	U
FOUNG	fort	lexicalisation	10	U
FUEDE	[fʊadeɪ]	near to target	1	U
FUEDE	feud	visual lexicalisation	2	U

Target	Production	Error Type	Participant	Body
FUEDE	feud	visual lexicalisation	3	U
FUEDE	swede	visual lexicalisation	5	U
FUEDE	no response		7	U
FUEDE	food	phonological lexicalisation	8	U
FUEDE	feud	visual lexicalisation	9	U
FUEDE	[fjʊdə]	near to target	10	U
GEASH	[dʒaʃ]	far from target	1	U
GEASH	great	lexicalisation	2	U
GEASH	gash	visual lexicalisation	5	U
GEASH	[gɪs]	near to target	6	U
GEASH	niece	perseveration	7	U
GEASH	[giʒ]	near to target	9	U
GEASH	[gɔsp]	far from target	10	U
GERP	[gɛrpə]	near to target	1	U
GERP	[gɛrb]	near to target	2	U
GERP	[gɛrf]	near to target	6	U
GERP	[hɛrp]	near to target	8	U
GERP	sherpa	visual lexicalisation	10	U
GOAP	[gɒpi]	near to target	1	U
GOAP	[gʊp]	near to target	3	U
GOAP	gulp	visual lexicalisation	7	U
GOAP	soap	visual lexicalisation	8	U
GOAP	goat	visual lexicalisation	10	U
GURNT	[gʊarnt]	near to target	1	U
GURNT	[gʌrt]	near to target	2	U
GURNT	grunt	visual lexicalisation	7	U
GURNT	[ʃʌgʌrv]	far from target	10	U

Target	Production	Error Type	Participant	Body
GURVE	[gʌf]	far from target	2	U
GURVE	sword	perseveration	7	U
GURVE	[ʃʊgɛrv]	near to target	10	U
GUSP	tape	perseveration	7	U
GUSP	just	lexicalisation	10	U
HOTHE	[hɔlheɪ]	far from target	1	U
HOTHE	oath	phonological lexicalisation	2	U
HOTHE	hot	visual lexicalisation	3	U
HOTHE	huffy	lexicalisation	4	U
HOTHE	[hɒtheɪ]	far from target	5	U
HOTHE	both	phonological lexicalisation	6	U
HOTHE	house	perseveration	7	U
HOTHE	[nɑnsə]	far from target	10	U
JIRP	[fɪlp]	far from target	1	U
JIRP	jip	visual lexicalisation	2	U
JIRP	[twɪnt]	far from target	6	U
JIRP	no response		7	U
JIRP	dirk	lexicalisation	8	U
JIRP	[tatə]	far from target	10	U
KEACE	[keɪaseɪ]	far from target	1	U
KEACE	[gɪnt]	far from target	2	U
KEACE	quiche	phonological lexicalisation	3	U
KEACE	quiche	phonological lexicalisation	4	U
KEACE	[fis]	near to target	6	U
KEACE	knee	lexicalisation	7	U
KEACE	[kifə]	near to target	10	U
KULF	no response		1	U

Target	Production	Error Type	Participant	Body
KULF	cull	visual lexicalisation	2	U
KULF	gulf	visual lexicalisation	3	U
KULF	no response		4	U
KULF	gulf	visual lexicalisation	5	U
KULF	[kʌrf]	near to target	6	U
KULF	no response		7	U
KULF	no response		8	U
KULF	no response		10	U
LEART	[lɛrt]	near to target	3	U
LEART	no response		6	U
LEART	lent	visual lexicalisation	7	U
LEART	heart	visual lexicalisation	8	U
LEART	learn	visual lexicalisation	10	U
LOURT	[lʊr]	near to target	2	U
LOURT	[lʌrt]	near to target	3	U
LOURT	[klɔrt]	near to target	6	U
LOURT	lower	lexicalisation	7	U
LOURT	[leʊt]	near to target	9	U
LOURT	[larə]	far from target	10	U
MAUCHE	[mɔkəʊbə]	far from target	2	U
MAUCHE	[mɔʃi]	far from target	3	U
MAUCHE	[mɑʃi]	far from target	4	U
MAUCHE	[mɔʃi]	near to target	5	U
MAUCHE	[bɔkt]		6	U
MAUCHE	no response		7	U
MAUCHE	[mɔʃ]	near to target	8	U
MAUCHE	[mɔç]	near to target	9	U

Target	Production	Error Type	Participant	Body
MAUCHE	[marɑ]	far from target	10	U
MOATHE	[məʊðɛrimʌs]	far from target	2	U
MOATHE	[məʊʃ]	near to target	3	U
MOATHE	[maØʊ]	far from target	4	U
MOATHE	[faʊØ]	far from target	6	U
MOATHE	no response		7	U
MOATHE	[meʊtə]	near to target	10	U
NAIST	[neɪs]	near to target	2	U
NAIST	[nast]	near to target	4	U
NAIST	nest	visual lexicalisation	5	U
NAIST	[nɪst]	near to target	6	U
NAIST	nails	visual lexicalisation	7	U
NAIST	nest	visual lexicalisation	8	U
NAIST	[neɪz]	near to target	9	U
NAIST	[nɛnə]	far from target	10	U
NIEST	niece	visual lexicalisation	2	U
NIEST	[nikt]	near to target	3	U
NIEST	[nisɛti]	far from target	5	U
NIEST	[nɪfst]	near to target	6	U
NIEST	niece	visual lexicalisation	7	U
NIEST	breast	lexicalisation	8	U
NIEST	[naɪɛst]	near to target	9	U
NIEST	nest	visual lexicalisation	10	U
NONGUE	[nɒŋweɪ]	near to target	1	U
NONGUE	[nʌk]	far from target	2	U
NONGUE	[mɔŋə]	near to target	3	U

Target	Production	Error Type	Participant	Body
NONGUE	[mɔŋ]	near to target	4	U
NONGUE	no response		7	U
NONGUE	[mɒŋ]	near to target	8	U
NONGUE	[nɔŋə]	near to target	9	U
NONGUE	[nɔŋsə]	near to target	10	U
NUGUE	[nɑgweɪ]	far from target	1	U
NUGUE	[nʊdʒɛnt]	far from target	2	U
NUGUE	[nʊdʒ]	near to target	3	U
NUGUE	[nugi]	near to target	4	U
NUGUE	tongue	lexicalisation	6	U
NUGUE	scatter	lexicalisation	7	U
NUGUE	[nʌg]	far from target	8	U
NUGUE	[nʌdʒə]	near to target	9	U
NUGUE	no response		10	U
NYRRH	[nɪrə]	near to target	1	U
NYRRH	[dʒɪkə]	far from target	2	U
NYRRH	mirror	lexicalisation	4	U
NYRRH	myrrh	visual lexicalisation	5	U
NYRRH	no response		7	U
NYRRH	myrrh	visual lexicalisation	8	U
NYRRH	[marə]	far from target	10	U
PILM	[pɪln]	near to target	1	U
PILM	[plɪm]	near to target	3	U
PILM	[pɪln]	near to target	4	U
PILM	[gɪln]	far from target	5	U
PILM	close	lexicalisation	7	U

Target	Production	Error Type	Participant	Body
PLINC	plank	lexicalisation	1	U
PLINC	[plɪntʃ]	near to target	3	U
PLINC	[plaɪn]	far from target	4	U
PLINC	[plɪkɪn]	far from target	5	U
PLINC	[slɪntʃ]	far from target	6	U
PLINC	plinth	visual lexicalisation	7	U
PLINC	zinc	visual lexicalisation	8	U
PLINC	[plɪnt]	near to target	9	U
PLINC	[plɛnɑ]	far from target	10	U
PUOY	[pʊɒp]	far from target	1	U
PUOY	buoy	phonological lexicalisation	2	U
PUOY	buoy	visual lexicalisation	6	U
PUOY	[kɔreɪ]	far from target	7	U
PUOY	buoy	visual lexicalisation	8	U
PUOY	[palɑ]	far from target	10	U
REARCH	no response		1	U
REARCH	no response		2	U
REARCH	no response		3	U
REARCH	no response		4	U
REARCH	no response		5	U
REARCH	no response		6	U
REARCH	horse	perseveration	7	U
REARCH	search	visual lexicalisation	8	U
REARCH	no response		9	U
REARCH	[rɛnsɑ]	far from target	10	U
RUCT	r.		2	U
RUCT	[rʌk]	near to target	4	U
RUCT	wrecked	phonological lexicalisation	5	U

Target	Production	Error Type	Participant	Body
RUCT	runt	visual lexicalisation	6	U
RUCT	[drʌsk]	far from target	7	U
RUCT	[rʌpt]	near to target	9	U
RUCT	rough	phonological lexicalisation	10	U
SAISLE	sizzle	phonological lexicalisation	2	U
SAISLE	sail	lexicalisation	3	U
SAISLE	[laɪəl]	near to target	6	U
SAISLE	heart	lexicalisation	7	U
SAISLE	aisle	visual lexicalisation	8	U
SAISLE	salsa	lexicalisation	10	U
SEARSE	[sir]	near to target	2	U
SEARSE	terse	phonological lexicalisation	4	U
SEARSE	search	visual lexicalisation	6	U
SEARSE	search	visual lexicalisation	7	U
SEARSE	hearse	visual lexicalisation	8	U
SEARSE	[ʃnɛrtz]	far from target	10	U
SILN	slate	lexicalisation	2	U
SILN	[slɪni]	near to target	3	U
SILN	slim	lexicalisation	7	U
SILN	[gɪln]	near to target	8	U
SILN	[smɒl]	far from target	10	U
SLEIL	[slɛl]	near to target	1	U
SLEIL	sleight	lexicalisation	2	U
SLEIL	slayed	phonological lexicalisation	3	U
SLEIL	[ʃiəl]	near to target	4	U
SLEIL	sleigh	visual lexicalisation	5	U
SLEIL	[sleɪdʒ]	far from target	7	U
SLEIL	kneel	phonological lexicalisation	8	U

Target	Production	Error Type	Participant	Body
SLEIL	[sliɑl]	near to target	9	U
SLEIL	[slɛpə]	far from target	10	U
SURVE	no response		1	U
SURVE	survive	visual lexicalisation	2	U
SURVE	surge	visual lexicalisation	3	U
SURVE	[slʌrv]	near to target	4	U
SURVE	no response		6	U
SURVE	no response		7	U
SURVE	[slavə]	far from target	10	U
SYPE	[sɪpa]	near to target	1	U
SYPE	slurp	lexicalisation	2	U
SYPE	[sɪpsi]	near to target	3	U
SYPE	swipe	visual lexicalisation	5	U
SYPE	type	visual lexicalisation	6	U
SYPE	no response		7	U
SYPE	[sɪlbə]	far from target	10	U
TESK	[tɛk]	near to target	3	U
TESK	[gɑsk]	far from target	5	U
TESK	desk	visual lexicalisation	6	U
TESK	desk	visual lexicalisation	7	U
TESK	desk	visual lexicalisation	8	U
TESK	[tɛlɪs]	far from target	10	U
TURZE	slur	lexicalisation	2	U
TURZE	[tʌrb]	near to target	3	U
TURZE	terse	phonological lexicalisation	4	U
TURZE	furze	visual lexicalisation	5	U
TURZE	furze	visual lexicalisation	6	U
TURZE	turn	visual lexicalisation	7	U

Target	Production	Error Type	Participant	Body
TURZE	[larə]	far from target	10	U

PSEUDOHOMOPHONE ERRORS

Target	Production	Error Type	Participant	Body
BENE	[bini]	near to target	3	C
BENE	[birɛla]	far from target	10	C
CIRL	girl	phonological lexicalisation	2	C
CIRL	[sɪrɪç]	far from target	5	C
CIRL	girl	visual lexicalisation	7	C
CIRL	[kʌlip]	far from target	10	C
FOAX	[fəʊnɔk]	far from target	2	C
FOAX	fox	visual lexicalisation	3	C
FOAX	fox	visual lexicalisation	7	C
FOAX	hoax	visual lexicalisation	8	C
FOAX	fax	visual lexicalisation	10	C
GEIGN	[dʒinɛ]	near to target	1	C
GEIGN	ginger	visual lexicalisation	2	C
GEIGN	[gɪn]	near to target	3	C
GEIGN	[gigɒn]	near to target	5	C
GEIGN	reign	visual lexicalisation	7	C
GEIGN	[gaɪn]	near to target	9	C
GEIGN	greta	lexicalisation	10	C
GILE	gill	visual lexicalisation	2	C
GILE	girls	lexicalisation	7	C
GRIECE	[grɪsp]	near to target	3	C
GRIECE	[grɪz]	near to target	9	C
GRIECE	[grika]	near to target	10	C
MIQUE	connect	lexicalisation	2	C
MIQUE	Mick	phonological lexicalisation	5	C

Target	Production	Error Type	Participant	Body
MIQUE	frock	lexicalisation	7	C
MIQUE	[smilki]	far from target	8	C
MIQUE	[paki]	far from target	10	C
NOAT	moat	visual lexicalisation	4	C
NOAT	moat	visual lexicalisation	7	C
NOAT	moat	visual lexicalisation	8	C
NOAT	[gɔli]	far from target	10	C
PADE	pad	visual lexicalisation	2	C
PADE	spade	visual lexicalisation	7	C
POAST	[dɒst]	near to target	2	C
POAST	[peʊɪst]	near to target	5	C
POAST	roast	visual lexicalisation	8	C
POAST	[pɔrtsə]	far from target	10	C
PUEL	[fʊɔl]	far from target	1	C
PUEL	[pʊə]	near to target	3	C
PUEL	power	lexicalisation	7	C
PUEL	ghoul	lexicalisation	8	C
PUEL	[pʊlə]	near to target	10	C
RECK	[reɪksə]	far from target	1	C
RECK	wreak	phonological lexicalisation	2	C
RECK	wreak	phonological lexicalisation	4	C
RECK	rake	phonological lexicalisation	5	C
RECK	rake	perseveration	7	C
RECK	reckon	visual lexicalisation	10	C
RIST	[glɪst]	near to target	3	C
RIST	resist	visual lexicalisation	5	C
RIST	[mist]	near to target	7	C

Target	Production	Error Type	Participant	Body
RIST	[rɪs]	near to target	10	C
SKAIL	skate	visual lexicalisation	2	C
SKAIL	kale	phonological lexicalisation	8	C
SKAIL	skill	lexicalisation	10	C
BEWN	[peɪwʌn]	far from target	1	I
BEWN	[plʊi]	far from target	2	I
BEWN	peach	perseveration	7	I
BEWN	[brʊinɒ]	far from target	10	I
BOAD	boast	visual lexicalisation	2	I
BOAD	[beʊɛdi]	far from target	5	I
BOAD	[heʊd]	near to target	8	I
BOAD	Paula	lexicalisation	10	I
BOUL	bowl	visual lexicalisation	1	I
BOUL	bull	phonological lexicalisation	2	I
BOUL	bowels	lexicalisation	4	I
BOUL	bowl	visual lexicalisation	7	I
BOUL	bull	phonological lexicalisation	8	I
BOUL	bull	visual lexicalisation	9	I
BOUL	bowl	visual lexicalisation	10	I
BRURY	burberry	lexicalisation	2	I
BRURY	brewer	lexicalisation	3	I
BRURY	[brʊlɛpa]	far from target	10	I
CEAR	pier	phonological lexicalisation	7	I
CEAR	clear	visual lexicalisation	8	I
CEAR	[gɛril]	far from target	10	I
CHEAF	[tʃivi]	near to target	2	I
CHEAF	chuff	visual lexicalisation	3	I
CHEAF	clef	visual lexicalisation	5	I

Target	Production	Error Type	Participant	Body
CHEAF	[ʃɛpf]	far from target	7	I
CHEAF	[tʃʊi]	far from target	10	I
CLEW	[klaɪʊ]	near to target	1	I
CLEW	cluedo	phonological lexicalisation	2	I
CLEW	[lɔrɪl]	far from target	10	I
CLIEVE	[tʃiv]	near to target	2	I
CLIEVE	cliff	visual lexicalisation	5	I
CLIEVE	cow	lexicalisation	7	I
CLIEVE	[kliva]	near to target	10	I
FEAK	freak	visual lexicalisation	4	I
FEAK	peak	visual lexicalisation	5	I
FEAK	freak	visual lexicalisation	7	I
FOME	form	visual lexicalisation	5	I
FOME	[rɔm]	far from target	10	I
FONE	[fɔrn]	near to target	5	I
FONE	foam	visual lexicalisation	7	I
GEAT	[gɛkt]	near to target	3	I
GEAT	gate	visual lexicalisation	5	I
GEAT	[lʊti]	far from target	10	I
GEIR	weir	visual lexicalisation	5	I
GEIR	heir	visual lexicalisation	8	I
GEW	skew	visual lexicalisation	2	I
GEW	know	lexicalisation	5	I
GEW	[miʊ]	far from target	7	I
GEW	brew	visual lexicalisation	10	I
GIEVE	[dʒivil]	far from target	1	I
GIEVE	[grɪb]	far from target	2	I

Target	Production	Error Type	Participant	Body
GIEVE	grave	visual lexicalisation	7	I
GIEVE	[grɪfɑ]	far from target	10	I
GLOUR	[glir]	near to target	1	I
GLOUR	[glir]	near to target	3	I
GLOUR	[glawə]	near to target	7	I
GOME	gnome	visual lexicalisation	3	I
GOME	gnome	visual lexicalisation	7	I
GOME	gnome	visual lexicalisation	8	I
GOME	[brɒm]	near to target	10	I
GOOL	[glʊl]	far from target	2	I
GOOL	[gɔlip]	far from target	10	I
GOST	[gɔst]	near to target	3	I
GOST	[gɔrst]	near to target	5	I
GOST	[grʌstɪp]	far from target	10	I
GOW	[gʊ]	near to target	1	I
GOW	cow	visual lexicalisation	7	I
GOW	[gripi]	far from target	10	I
GRIMB	[grɪmə]	near to target	1	I
GRIMB	[grɪmbəl]	near to target	2	I
GRIMB	ground	lexicalisation	7	I
GRIMB	[gripar]	far from target	10	I
GROMB	grommit	visual lexicalisation	2	I
GROMB	gromit	visual lexicalisation	10	I
HOMB	[hɔrb]	near to target	5	I
HOMB	comb	visual lexicalisation	7	I
HOMB	tomb	visual lexicalisation	8	I

Target	Production	Error Type	Participant	Body
HOMB	[hɔmbə]	near to target	10	I
HOUCH	[hʌrnsi]	far from target	1	I
HOUCH	[gɒtʃ]	near to target	2	I
HOUCH	hock	visual lexicalisation	3	I
HOUCH	ouch	visual lexicalisation	4	I
HOUCH	gauche	phonological lexicalisation	5	I
HOUCH	couch	visual lexicalisation	7	I
HOUCH	touch	visual lexicalisation	8	I
HOUCH	[hɔri]	far from target	10	I
JEAR	[dʒeɪə]	near to target	1	I
JEAR	jar	visual lexicalisation	5	I
JEAR	[dʒɔr]	near to target	10	I
KAND	candy	phonological lexicalisation	2	I
KAND	hand	visual lexicalisation	7	I
KAND	[nakə]	far from target	10	I
LASTE	[listə]	near to target	2	I
LASTE	last	visual lexicalisation	3	I
LASTE	[lɑsti]	near to target	5	I
LASTE	lost	visual lexicalisation	7	I
LASTE	taste	visual lexicalisation	8	I
LEAT	lent	visual lexicalisation	2	I
LEAT	lean	visual lexicalisation	7	I
LEAT	heat	visual lexicalisation	8	I
LEIGHT	[leɪgɛt]	near to target	1	I
LEIGHT	lay	phonological lexicalisation	2	I
LEIGHT	[lɛkt]	near to target	3	I
LEIGHT	height	visual lexicalisation	8	I

Target	Production	Error Type	Participant	Body
LEIGHT	[lɛrpə]	far from target	10	I
LEIR	[neɪɑd]	near to target	1	I
LEIR	lier	visual lexicalisation	2	I
LEIR	mayor	phonological lexicalisation	7	I
LEIR	tear	phonological lexicalisation	8	I
LEIR	[lɛpi]	far from target	10	I
LERE	learn	phonological lexicalisation	2	I
LOWN	lawn	visual lexicalisation	1	I
LOWN	[lɛʊin]	near to target	2	I
LOWN	lawn	visual lexicalisation	7	I
LOWN	gown	visual lexicalisation	8	I
LOWN	loaned	lexicalisation	10	I
MEIGHT	[mɪgil]	far from target	1	I
MEIGHT	met	phonological lexicalisation	2	I
MEIGHT	[mɛkt]	near to target	3	I
MEIGHT	meat	phonological lexicalisation	4	I
MEIGHT	[mɛti]	near to target	9	I
MEIGHT	[mɪkanɑ]	far from target	10	I
MOWL	[nɔl]	near to target	2	I
MOWL	[mɔw]	near to target	7	I
MOWL	mull	visual lexicalisation	8	I
MOWL	[mɔl]	near to target	10	I
MUIT	[mʊət]	near to target	3	I
MUIT	met	visual lexicalisation	10	I
NEAD	head	visual lexicalisation	8	I
NEAD	dead	visual lexicalisation	10	I
NERE	[nɔrɪ]	near to target	2	I

Target	Production	Error Type	Participant	Body
NERE	[nɛrʊ]	near to target	5	I
NERE	niece	lexicalisation	7	I
NERE	[mirə]	near to target	8	I
NEWN	[nʊpi]	far from target	2	I
NEWN	[njim]	far from target	4	I
NEWN	now	lexicalisation	7	I
NEWN	tune	phonological lexicalisation	8	I
NEWN	Newton	visual lexicalisation	10	I
NOWN	now	phonological lexicalisation	7	I
NOWN	gown	visual lexicalisation	8	I
NOWN	gromit	perseveration	10	I
POOT	[pʊit]	near to target	1	I
POOT	boot	phonological lexicalisation	2	I
POOT	foot	visual lexicalisation	4	I
POOT	pout	visual lexicalisation	7	I
POOT	root	visual lexicalisation	8	I
POOT	[pitʃip]	far from target	10	I
PORSE	porsche	visual lexicalisation	7	I
PORSE	horse	visual lexicalisation	8	I
PREAST	breast	visual lexicalisation	2	I
PREAST	[praɪɛst]	near to target	5	I
PREAST	breast	visual lexicalisation	8	I
PREAST	[prɛstə]	near to target	10	I
REAK	[dik]	near to target	2	I
REAK	[rikɒ]	near to target	4	I
REAK	wreck	phonological lexicalisation	5	I
REAK	rack	phonological lexicalisation	7	I

Target	Production	Error Type	Participant	Body
REAK	rack	phonological lexicalisation	10	I
ROUR	[rʊ]	near to target	1	I
ROUR	cower	phonological lexicalisation	2	I
ROUR	[rʊir]	near to target	4	I
ROUR	our	visual lexicalisation	7	I
ROUR	[rɛrin]	far from target	10	I
SERE	[kir]	near to target	3	I
SERE	[sirɑ]	near to target	5	I
SERE	Fay	lexicalisation	7	I
SERE	search	lexicalisation	10	I
SHEAT	[ʃiɑp]	near to target	1	I
SHEAT	[ʃir]	far from target	2	I
SHEAT	heat	visual lexicalisation	8	I
SHEAT	[ʃipar]	far from target	10	I
SIVE	give	visual lexicalisation	3	I
SIVE	[sif]	near to target	7	I
SIVE	dive	visual lexicalisation	8	I
SIVE	[sɛvar]	far from target	10	I
SNOUP	[ʃɑp]	far from target	2	I
SNOUP	[snɔp]	near to target	5	I
SNOUP	meat	lexicalisation	7	I
SNOUP	[snipə]	far from target	10	I
SNUISE	[saɪsi]	far from target	2	I
SNUISE	[ʃis]	far from target	4	I
SNUISE	[nəmizi]	far from target	5	I
SNUISE	Louise	visual lexicalisation	8	I

Target	Production	Error Type	Participant	Body
SNUISE	[simɛrtə]	far from target	10	I
SORD	sword	visual lexicalisation	4	I
SORD	[sɔrti]	near to target	10	I
SOUGH	[ʃʌgi]	far from target	1	I
SOUGH	sour	visual lexicalisation	3	I
SOUGH	[slɒf]	near to target	4	I
SOUGH	cough	visual lexicalisation	8	I
SOUGH	slipper	lexicalisation	10	I
TOWL	[tɒl]	near to target	4	I
TOWL	cow	lexicalisation	9	I
TOWL	[tɔlə]	far from target	10	I
WURY	[lʌri]	near to target	2	I
WURY	[tʌri]	near to target	8	I
WURY	[wati]	far from target	10	I
BAOL	bowel	lexicalisation	1	U
BAOL	bowl	visual lexicalisation	3	U
BAOL	bowl	visual lexicalisation	4	U
BAOL	bull	visual lexicalisation	5	U
BAOL	bowl	visual lexicalisation	7	U
BAOL	[bɔlap]	far from target	10	U
BRINC	brine	visual lexicalisation	5	U
BRINC	mine	lexicalisation	7	U
BUCT	[bjʊgɪt]	far from target	1	U
BUCT	duct	visual lexicalisation	2	U
BUCT	but	visual lexicalisation	5	U
BUCT	cow	perseveration	7	U
BUCT	[baka]	far from target	10	U

Target	Production	Error Type	Participant	Body
FAISLE	fails	visual lexicalisation	3	U
FAISLE	[fals]	far from target	4	U
FAISLE	[fɛrɪsə]	far from target	5	U
FAISLE	fair	visual lexicalisation	7	U
FAISLE	fail	visual lexicalisation	8	U
FAISLE	[feɪsɪl]	near to target	9	U
FAISLE	false	visual lexicalisation	10	U
FLEGM	[lɛgəm]	near to target	1	U
FLEGM	[elamɛtə]	far from target	2	U
FLEGM	[gleɪmən]	far from target	5	U
FLEGM	[fəlina]	far from target	10	U
FLOUBT	[flɔɑk]	far from target	1	U
FLOUBT	flown	visual lexicalisation	2	U
FLOUBT	[flɔbɛt]	near to target	3	U
FLOUBT	[flabʌt]	far from target	4	U
FLOUBT	[flʊbət]	far from target	5	U
FLOUBT	[fleʊb]	near to target	7	U
FLOUBT	[flarbə]	far from target	10	U
FYLE	[filɪ]	near to target	1	U
FYLE	foil	phonological lexicalisation	4	U
FYLE	[falip]	far from target	10	U
FYRRH	[firʌha]	near to target	1	U
FYRRH	[fɪrʌt]	far from target	4	U
FYRRH	[sirɛç]	far from target	5	U
FYRRH	myrrh	visual lexicalisation	8	U
FYRRH	fire	phonological lexicalisation	9	U

Target	Production	Error Type	Participant	Body
FYRRH	[fɪrərə]	far from target	10	U
GEYE	[gɪsi]	far from target	2	U
GEYE	he	lexicalisation	3	U
GEYE	geese	lexicalisation	7	U
GEYE	eye	visual lexicalisation	8	U
GEYE	[grisə]	far from target	10	U
GOUN	[glɔn]	near to target	1	U
GOUN	grouch	lexicalisation	2	U
GOUN	[gɔn]	near to target	7	U
GOUN	[apɛni]	far from target	10	U
HACHM	[paramə]	far from target	2	U
HACHM	hack	visual lexicalisation	4	U
HACHM	[haʃəm]	near to target	5	U
HACHM	meat	lexicalisation	7	U
HACHM	hack	visual lexicalisation	10	U
HACHT	[hasɛt]	far from target	1	U
HACHT	[açt]	near to target	2	U
HACHT	hatch	visual lexicalisation	3	U
HACHT	[haʃip]	far from target	5	U
HACHT	[hɒkip]	far from target	7	U
HACHT	[higɪn]	far from target	10	U
LEBT	[neɪbɪt]	far from target	1	U
LEBT	levy	visual lexicalisation	2	U
LEBT	[lɛbɪt]	near to target	3	U
LEBT	[lɛbɪt]	near to target	5	U
LEBT	lemon	lexicalisation	7	U
LEBT	debt	visual lexicalisation	8	U

Target	Production	Error Type	Participant	Body
LEBT	[lɛbɛd]	near to target	9	U
LEBT	[lɛbɪnɒ]	far from target	10	U
MEIL	meal	visual lexicalisation	2	U
MEIL	meal	visual lexicalisation	3	U
MEIL	mill	phonological lexicalisation	5	U
MEIL	meal	visual lexicalisation	7	U
MEIL	meal	visual lexicalisation	8	U
MEIL	meal	visual lexicalisation	9	U
MEIL	[lalə]	far from target	10	U
MIGN	[mig]	near to target	2	U
MIGN	[mɪn]	near to target	3	U
MIGN	Ming	visual lexicalisation	4	U
MIGN	[mɪgən]	near to target	5	U
MIGN	[mɔk]	lexicalisation	10	U
NEACE	[neɪɑk]	near to target	1	U
NEACE	mess	visual lexicalisation	5	U
NEUE	[neɪp]	far from target	1	U
NEUE	[glɪs]	far from target	2	U
NEUE	[nʊi]	near to target	3	U
NEUE	news	phonological lexicalisation	4	U
NEUE	meow	lexicalisation	7	U
NEUE	[nipə]	far from target	10	U
PAIST	[prɛpɪs]	far from target	2	U
PAIST	past	visual lexicalisation	3	U
PAIST	[piɛst]	near to target	5	U
PAIST	post	visual lexicalisation	7	U
PAUZE	[paz]	near to target	1	U

Target	Production	Error Type	Participant	Body
PAUZE	porsche	perseveration	7	U
PAUZE	Paul	visual lexicalisation	8	U
PAUZE	[pɪstə]	far from target	10	U
PEARCH	[peɪarsə]]	far from target	1	U
PEARCH	parch	visual lexicalisation	3	U
PEARCH	porsche	perseveration	7	U
PEARCH	search	visual lexicalisation	8	U
PEARCH	[pitʃə]	near to target	10	U
POAP	pop	visual lexicalisation	3	U
POAP	soup	lexicalisation	7	U
POAP	soap	visual lexicalisation	8	U
POAP	[pɔrsi]	near to target	10	U
ROUNG	round	visual lexicalisation	2	U
ROUNG	ground	visual lexicalisation	4	U
ROUNG	[rʊntʃə]	far from target	5	U
ROUNG	rota	lexicalisation	10	U
SNYPE	[snɪrpə]	far from target	1	U
SNYPE	[sɪnɛp]	far from target	4	U
SNYPE	[gaɪp]	near to target	8	U
SNYPE	[slakə]	far from target	10	U
SOURT	[sʊɛrt]	near to target	1	U
SOURT	[ʃirlink]	far from target	2	U
SOURT	sour	visual lexicalisation	3	U
SOURT	[sʌrt]	near to target	4	U
SOURT	cow	perseveration	7	U
SOURT	[seʊt]	near to target	8	U
SOURT	[sʌrt]	near to target	9	U

Target	Production	Error Type	Participant	Body
SOURT	slurp	lexicalisation	10	U
STEART	[sir]	far from target	2	U
STEART	[stit]	near to target	3	U
STEART	street	phonological lexicalisation	4	U
STEART	charge	lexicalisation	5	U
STEART	Stuart	visual lexicalisation	7	U
STEART	heart	visual lexicalisation	8	U
STEART	[stali]	far from target	10	U
WOSP	worst	visual lexicalisation	5	U
WOSP	swop	phonological lexicalisation	7	U
WOSP	[rɒsp]	near to target	8	U
WOSP	[wʌlpə]	far from target	10	U
WUEDE	went	lexicalisation	2	U
WUEDE	suede	visual lexicalisation	8	U
WUEDE	[wʌrdə]	near to target	10	U
YIEST	[jɪst]	near to target	1	U
YIEST	[jʊɪlɪst]	far from target	2	U
YIEST	[gɪst]	far from target	3	U
YIEST	[jils]	far from target	5	U
YIEST	use	lexicalisation	7	U
YIEST	[fɛst]	far from target	10	U
YONGUE	[jiŋfʊ]	far from target	2	U
YONGUE	[jʌŋɒ]	near to target	3	U
YONGUE	jug	lexicalisation	5	U
YONGUE	rowan	lexicalisation	7	U
YONGUE	[ɔtila]	far from target	10	U

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